AMBIENT AIR QUALITY IN WINDSOR AND VICINITY

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Ontario
Ministry of the Environment

The Honourable
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Minister

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IN
WINDSOR AND VICINITY

Annual Report 1982

Technical Support Section
Southwestern Region

ONTARIO MINISTRY OF THE ENVIRONMENT
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TABLE OF CONTENTS

TABLE OF CONTENTS - continued

SUMMARY

Air quality monitoring conducted in the Windsor area by the Ministry of the Environment revealed satisfactory air quality with respect to many air pollutants and improved air quality in 1982 compared to 1981. Levels of sulphur dioxide, carbon monoxide, oxides of nitrogen, heavy metals and fluorides were satisfactory.

During 1982, certain areas of Windsor experienced levels of dustfall and total suspended particulate matter in excess of the criteria for desirable ambient air quality. However, overall there was a general improvement in particulate levels and in 1982 levels were the lowest since monitoring began in the Windsor area. A notable exception to the general improvement is an increase in levels of total suspended particulates at station 12013 compared to 1981 levels. Station 12013 is located near the casting plant of Ford Motor Company of Canada, Limited which operated at much lower production in 1981 compared to 1982. However, the 1982 levels of suspended particulates at station 12013 are much lower than those levels recorded for the 1970's. The Ministry is seeking additional controls for particulate emissions from the casting plant.

Emissions from industries in the downriver area of Wayne County, Michigan adversely impact west Windsor. Michigan has a number of control programs for major sources of pollution in this area and is developing a program to control certain fugitive sources. These programs are necessary in order to comply with the primary air quality standards of the U.S. Environmental Protection Agency.

Malodours in west Windsor are in part attributable to ambient levels of total reduced sulphur compounds emitted from the Zug Island area of Michigan. Levels of total

reduced sulphurs monitored in west Windsor were appreciably lower in 1982 compared to 1981 but again higher values were experienced when winds were blowing from the direction of Zug Island.

Although 1982 experienced the fewest number of excursions above the criterion for desirable ambient air quality established for ozone, the number of excursions are unsatisfactory. Elevated levels are partly a result of local emissions but to a greater degree are a result of the long-range transport of oxidants and precursor chemicals into the Windsor area. Ontario has established a special section in its Long-Range Transport of Air Pollutants program to study the oxidant situation and to develop an appropriate control strategy. The U.S. Environmental Protection Agency is requiring individual states to implement oxidant control strategies by 1987.

INTRODUCTION

The Ontario Ministry of the Environment operates a network of ambient air monitors in the Windsor area to measure levels of a number of pollutants that may adversely affect health, vegetation or the enjoyment of property. Data on the levels of pollutants are compared with Ontario's criteria for desirable ambient air quality. Data are also used to determine trends in air quality and therefore the effectiveness of pollution abatement. As well, information is provided on the effects of specific sources of pollutants and for use in the formulation of strategies to control emission sources. The air quality monitoring program is complemented by the Ministry's phytotoxicology surveys which determine effects of air pollutants on vegetation.

In the past, the Ministry has received a number of complaints about odours when winds have been blowing towards west Windsor from the general direction of Zug Island. For several weeks in 1981 and again in 1982 mobile air monitoring vans were deployed by the Ministry to attempt to identify the constituent or constituents in the ambient air causing the offensive odours. Unfortunately, meteorological conditions were not conducive to identifying the causes of the malodorous conditions. Windsor District Office staff are attempting to collect samples of the malodorous air using adsorbent cartridges. If the samples can be successfully collected, the cartridges will be sent to the Ministry laboratories to identify the chemical compounds present.

In accordance with the Memorandum of Understanding on Transboundary Air Pollution Control in Southwestern Ontario - Southeastern Michigan signed in 1974 by Premier Davis and Governor Milliken, there are regular exchanges of both air quality data and reports on progress of compliance

with abatement schedules. The information exchanged has been used by the International Joint Commission, the International Michigan-Ontario Air Board and the Michigan-Ontario Transboundary Air Pollution Committee to prepare annual reports on air quality and pollution abatement programs.

This annual report deals more specifically and comprehensively with ambient air quality in the Windsor area than do the international reports.

DESCRIPTION OF MONITORING NETWORK

The Ministry operates continuous and intermittent ambient air monitors at fixed sites throughout the Windsor area. Ideally, monitoring would be conducted at the same sites year after year in order to provide a historical trend for air quality. However, many stations have had to be relocated or terminated because of local interferences or changing land-use patterns. Nevertheless, the number of existing historical stations is deemed adequate to evaluate the long-term trend in levels of pollutants.

Monitoring sites are distributed more densely in the downtown area where emissions from motor vehicles and commercial establishments are most prevalent and in west Windsor, which is close to a heavily industrialized portion of Wayne County, Michigan. Station 12014, which had been in operation since 1971 through cooperation with the University of Windsor, was terminated in 1982 because of a major change in land use.

The locations of the Ministry's monitoring stations in the Windsor area are indicated on Figure 1 and are described in Table A1 of Appendix 1. Also shown in

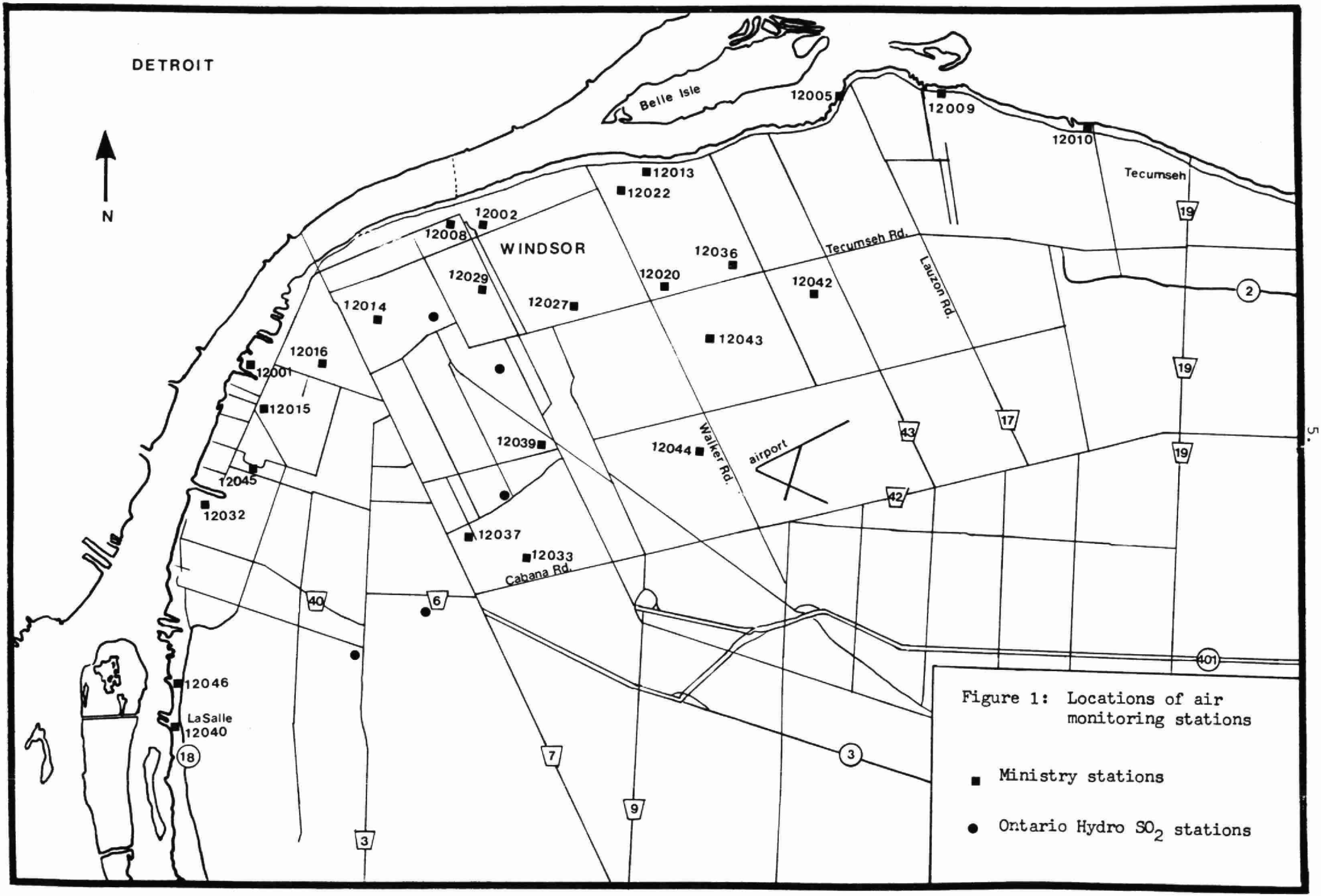


Figure 1: Locations of air monitoring stations

■ Ministry stations

● Ontario Hydro SO_2 stations

Figure 1 are the locations of 5 monitoring sites at which Ontario Hydro operates sulphur dioxide monitors. The sulphur dioxide monitors of Ontario Hydro are located in different directions from the J. C. Keith Generating Station at distances ranging from 5 to 7 kilometres.

The pollutants monitored at the various Ministry stations are indicated in Appendix 1, Table A2. Ontario's criteria for desirable ambient air quality with respect to these pollutants and the prime factors supporting these criteria are contained in Appendix 1, Table A3.

METEOROLOGICAL DATA

Meteorological data for 1982 were obtained from station 12001 in west Windsor. Station 12001 has meteorological equipment operated by Ontario Hydro. Wind speed, wind direction and ambient temperature are measured continuously at 18 metres above ground level. At 80 metres above ground level the difference between the temperature at the 80-metre level and the 18-metre level is determined. Wind speed and direction are measuredat the 80-metre level. The meteorological data are telemetred 12 times per hour to a computer of the Ministry in Toronto.

During 1982 a number of problems occurred at station 12001 which resulted in the loss of appreciable amounts of meteorological data. Prior to 1981, meteorological data were obtained from stations 12032 and 12034 but in 1980 it was necessary to suspend measurement of meteorological parameters at these sites.

Meteorological data are correlated with other pollutants such as suspended particulates, sulphur dioxide

and ozone to determine sources of pollutants. The data are also used to forecast dispersion conditions in association with the Air Pollution Index.

MONITORING AND PROGRAM RESULTS

PARTICULATES

The iron and steel industry, foundries, power generating plants utilizing fossil fuels and road traffic are primary sources of particulates that adversely affect air quality in Windsor. Wind-blown particles from open fields, sand and coal piles, roadways and roofs are also significant sources.

Measurements for particulates are reported as suspended particulates, dustfall and soiling index. Levels of suspended particulates are determined by drawing measured volumes of air through a filter for 24 hours and subsequently weighing the quantity of particulates collected on the filter.

Dustfall is measured by exposing an open cylinder (jar) of known diameter for 30 days and subsequently weighing the amount of particulates collected in the jar. This is a simple but crude sampling technique which is subject to many interferences and inaccuracies. Nevertheless, it does serve to show a general historical trend and relative levels of particulates throughout the Windsor area.

Soiling index is determined by measuring the difference in the amount of light transmitted through a filter before and after ambient air is drawn through the filter for 1 hour. The amount of light transmitted through the filter is affected by the quantity, size, shape and

opaqueness of particulates retained on the filter. Light transmitted through the filter is measured by a photoelectric cell and the soiling index may be calculated immediately. This immediate availability of the soiling index in contrast with the time-consuming laboratory analysis required for total suspended particulate measurements has resulted in soiling index being used in the Air Pollution Index as an indicator of levels of suspended particulates.

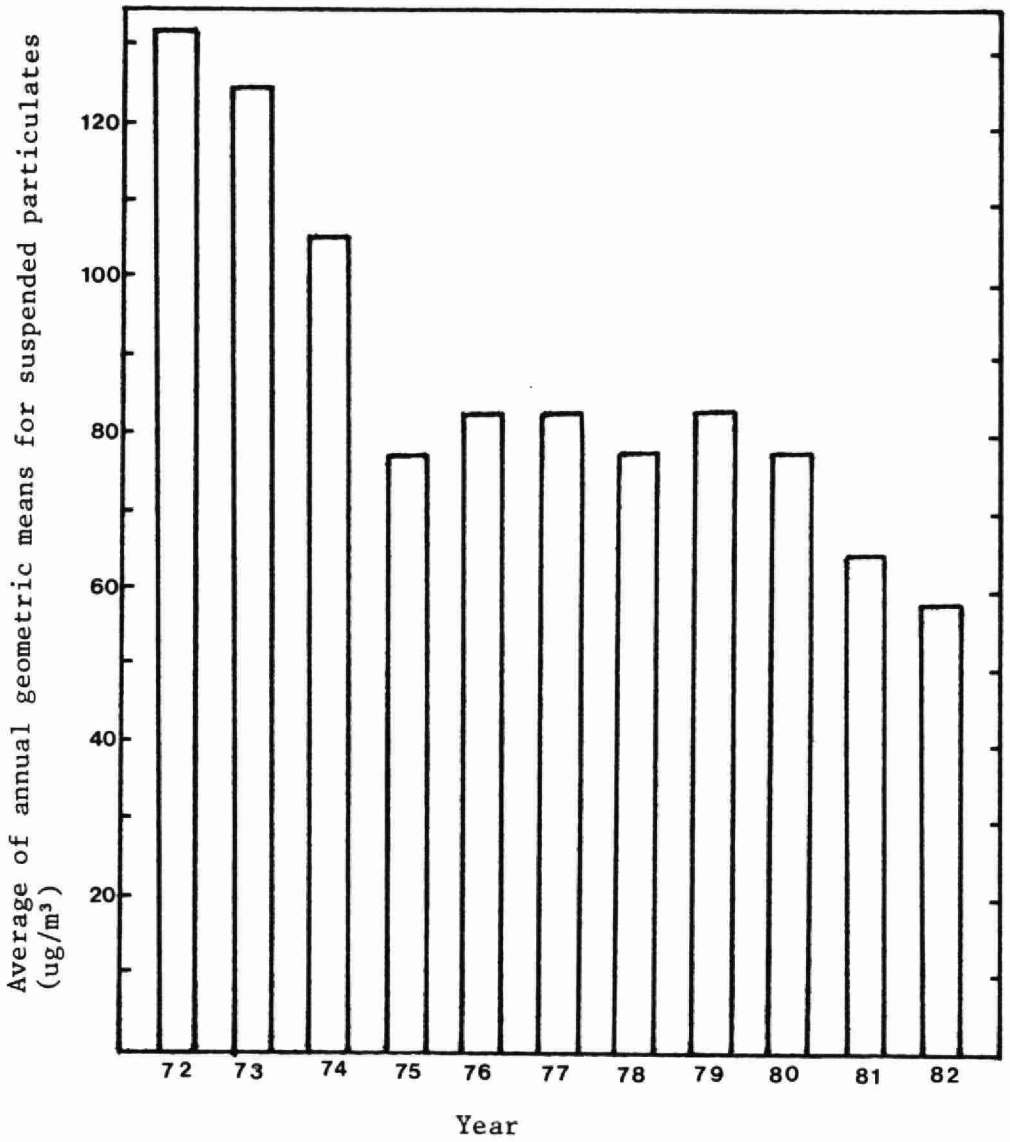
Suspended Particulates

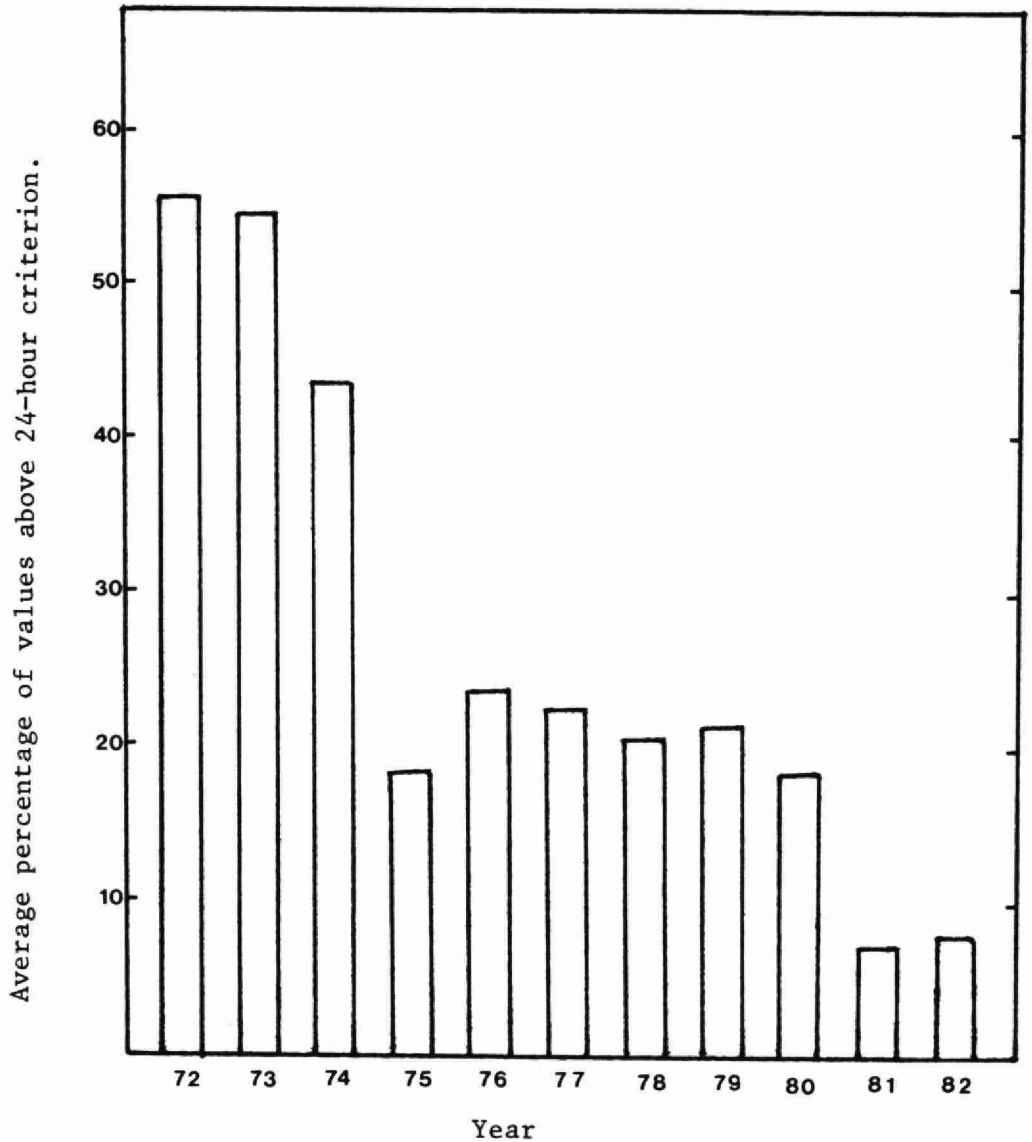
Two criteria for desirable ambient air quality exist for total suspended particulate matter. One is 120 micrograms of suspended particulates per cubic metre of air (ug/m^3) averaged over a 24-hour period. The other is an annual geometric mean of 60 ug/m^3. The criterion for 24 hours is based on impairment of visibility and adverse health effects associated with combined concentrations of sulphur dioxide and suspended particulates. The annual criterion is based on public awareness of suspended particulates and property damage.

During 1982 filters were exposed to collect suspended particulate matter at 13 sites in the Windsor area. At all sites except station 12008 samples were collected on a frequency of every sixth day. At station 12008 sampling was conducted every day to provide information by which the representativeness of the every-sixth-day sampling schedule could be judged.

During 1982 the measured levels of total suspended particulate matter were generally lower than in previous years. The degree of improvement in total suspended particulate levels is illustrated in Figure 2 which shows the

Figure 2. Trend in levels of suspended particulates based on average data from eight monitoring stations.





average of the annual geometric means and the average of the frequency of values above the 24-hour criterion for 8 monitoring stations in operation since 1972.

The improvement is further shown by the annual criterion for desirable ambient air quality being achieved at 7 sites in 1982 compared to 6 sites in 1981 and 4 sites in 1980. The best record prior to 1980 was to meet this criterion at 2 sites. The average of the annual geometric means reported for 1982 is below 60 ug/m^3, the criterion for desirable ambient air quality. Prior to 1982 the averages of the annual geometric means were above 60 ug/m^3. A summary of the data for 1972 to 1982 is presented in Table 1.

A notable exception to the improvement in total suspended particulate levels was recorded at station 12013, located near the casting plant of Ford Motor Company of Canada, Limited. Levels for 1982 did not compare favourably with 1981 levels. Station 12013 was the only site in Windsor that had a greater annual geometric mean in 1982 than in 1981. It should be noted that the increase was small, increasing from 65 ug/m^3 in 1981 to 68 ug/m^3 in 1982. Also, the frequency of excursions above the 24-hour criterion increased to 18 percent in 1982 from 5 percent in 1981. The 18 percent frequency was the greatest for any monitoring station in Windsor during 1982. The only known change in the area that may account for the increased levels of particulates between 1982 and 1981 is that the casting plant was shut-down for part of 1981 and operated at higher production levels in 1982. Despite the increases at station 12013 in 1982, the levels of annual geometric means reported for recent years have been essentially half of the levels reported for 1972 and 1973 and the frequency of excursions above the 24-hour criterion have been much less in recent

Table 1. Summary of data for total suspended particulates.

Station	Year										
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
	Annual geometric means (ug/m³)										
12002	159	133	108	74	76	82	79	80	77	69	62
12005							I.D.	63	55	45	45
12008	126	126	116	82	80	87	80	80	71	58	55
12008S											58
12009	79	82	61	52	58	54	52	57	58	46	46
12010	85	86	58	46	54	47	46	53	47	40	39
12013	151	145	113	89	98	113	100	98	75	65	68
12014	152	148	139	95	94	96	77	103	92	74	71
12015	183	147	152	105	113	93	93	98	108	87	70
12016				88	88	95	84	85	83	67	63
12032	126	120	94	81	89	93	79	84	(88)	72	61
12036						72	63	72	70	55	53
12037						67	68	62	60	49	39
12039								79	71	71	53
	Percentage of values above 24-hour criterion										
12002	70	58	43	14	15	21	18	16	19	9	11
12005							4	4	2	2	2
12008	57	55	47	17	19	24	16	17	12	6	4
12008S											4
12009	16	25	10	2	5	7	9	4	9	0	4
12010	23	27	17	2	10	6	7	0	0	0	0
12013	65	69	44	26	37	40	40	42	15	5	18
12014	70	72	64	25	26	26	20	41	23	13	11
12015	80	66	84	33	42	25	27	33	46	16	8
12016				20	24	22	23	20	20	6	5
12032	53	53	30	21	27	25	19	16	(20)	7	5
12036						11	9	15	13	2	2
12037						10	15	2	2	2	2
12039								14	8	3	6

I.D. - Insufficient data to compute a representative geometric mean.

( ) - Annual geometric mean and percentage of values above 24-hour criterion based on data not representative of total year.

Data for station 12008S are every-sixth-day sampling results extracted from the daily sampling data for station 12008.

years. The Ministry has requested Ford Motor Company of Canada, Limited to review sources of particulate emissions with the objective to develop additional control measures.

With the exception of the levels of total suspended particulates measured at station 12013, levels of total suspended particulates tend to be higher at monitoring sites in west Windsor than other areas of Windsor. Figure 3 illustrates the annual geometric mean concentrations and the percent frequencies of excursions above the 24-hour criterion at the approximate locations of the monitoring stations. Part of the reason for higher levels of particulates in west Windsor is attributable to emissions from the heavily industrialized area of Wayne County, which is located across the Detroit River from west Windsor. Michigan has a number of control strategies underway for point sources of particulate emissions in this area. Also, Michigan is actively pursuing a control strategy for fugitive emissions. Michigan must reduce the ambient levels of suspended particulates in Wayne County in order to comply with the standards of the U.S. Environmental Protection Agency.

In past years correlations between wind direction and levels of total suspended particulates have shown that at all stations higher levels of total suspended particulates are generally associated with southerly winds. At stations in west Windsor higher levels are associated with winds blowing from the heavily industrialized area of Wayne County. The higher levels associated with southerly winds have been attributed, in part, to long-range transport of aerosols including sulphates and products of photochemical reactions. For 1982 the stations in west Windsor show generally stronger correlations for winds blowing from the industrialized area of Wayne County. However, the 1982 data do not provide comparably strong correlations for southerly

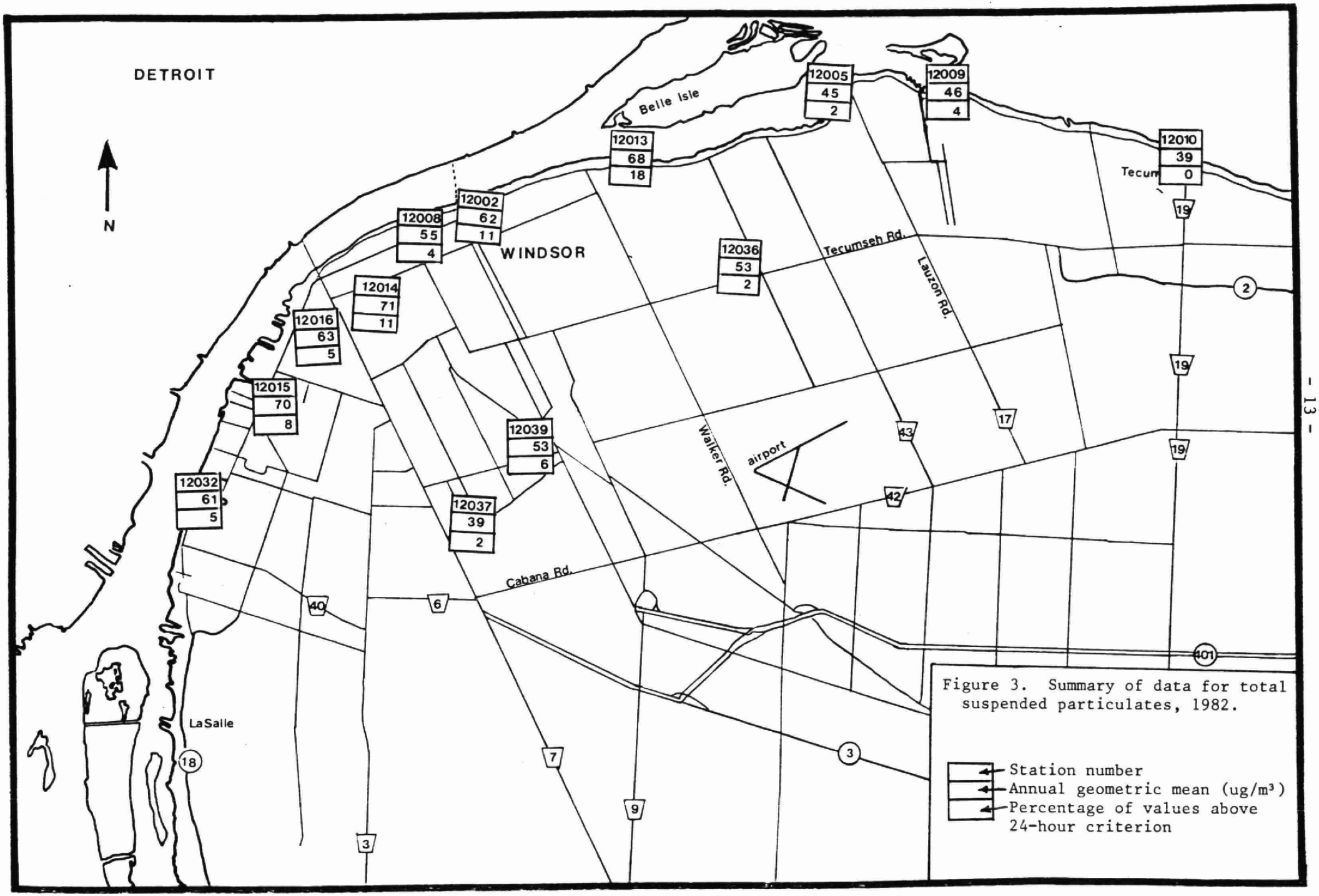


Figure 3. Summary of data for total suspended particulates, 1982.

winds as in previous years. This is not totally surprising since levels of sulphates and oxidants were lower in 1982 which suggests a lower impact from long-range transport. The highest correlations for station 12013 are associated with winds blowing from the casting plant of Ford Motor Company of Canada, Limited. Figure 4 provides the relative correlations at each monitoring station for 1982 data. The longer the line the higher the correlation.

The daily sampling at station 12008 reveals that the every-sixth-day sampling schedule utilized for the other monitoring sites during 1982 would provide annual geometric means and frequencies of excursions above the 24-hour criterion that were representative for the year. The annual geometric mean for station 12008 based on daily sampling is 55 ug/m^3 compared to 58 ug/m^3 which is the annual geometric mean calculated from the every-sixth-day schedule. Both the daily and the every-sixth-day sampling schedules at station 12008 resulted in 4 percent of the total suspended particulate levels exceeding the 24-hour criterion.

A certain amount of the total suspended particulate loading collected on the hi-vol filters is attributable to passive loading. Passive loading refers to particulates deposited on the filter when it is not in its 24-hour sampling phase. A study at station 12015 during 1982 revealed that the passive loading was 12.5 percent. If the passive loading were subtracted from the annual geometric mean for 1982 the mean would be reduced to 62 ug/m^3 from 70 ug/m^3. A device to shield the filter from the passive loading is to be installed on the hi-vol samplers in the near future.

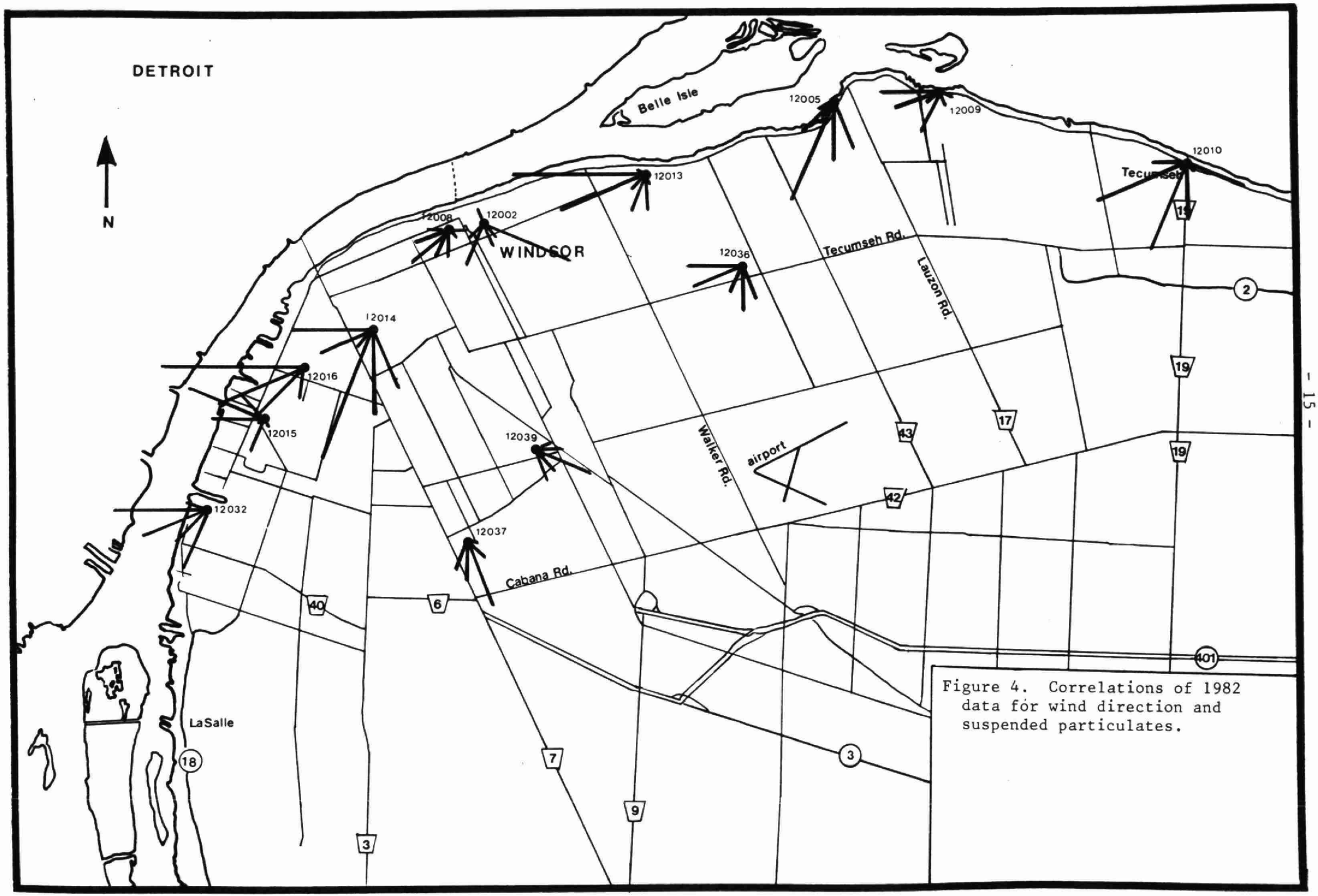


Figure 4. Correlations of 1982 data for wind direction and suspended particulates.

Chemical Analysis of Suspended Particulates

As part of a Province-wide study, samples of suspended particulates collected at 7 stations in Windsor were analyzed quantitatively for cadmium, chromium, copper, iron, lead, manganese, nickel, nitrates, sulphates and vanadium. In addition, samples for fewer analyses were collected at 4 additional stations. A summary of these data collected from 1976 through 1982 is presented in Appendix 2, Table A4. Data for sulphates are erroneously high based on the findings of several studies of the sampling method utilized by the Ministry. The Ministry is currently investigating different filter media which may lead to more accurate results.

Criteria for desirable ambient air quality exist for cadmium, lead, nickel and vanadium (see Table A3). Concentrations of the various metals have been traditionally low with no values above the criteria.

Iron levels reported for station 12039 were appreciably lower in 1981 and 1982 than in 1976 through 1980. Station 12039 is located near the scrap metal recycling operation of Zalev Bros. Ltd. and the lower levels indicate better control of emissions from this operation. Similarly, iron levels at station 12013 were lower in 1980 to 1982 than in 1976 to 1979. In part, the lower levels of iron may be attributable to lower emissions because of lower production at the casting plant of Ford Motor Company of Canada, Limited as well as better pollution control facilities at this plant.

Dustfall

The criteria for desirable ambient air quality established for dustfall are a 30-day loading of 7.0 grams

of dustfall per square metre ($g/m^2/30$ days) and an annual average of 4.6 $g/m^2/30$ days. These criteria were established on the basis of historical data and standards developed by other regulatory agencies.

In general, dustfall levels have been decreasing in recent years. The trend towards lower levels of dustfall is illustrated in Figure 5, which shows a decrease in the arithmetic mean of annual averages for 14 monitoring sites which have been in operation since 1972. A decrease in the arithmetic mean for the frequencies of excursions above the 30-day criterion is also evident.

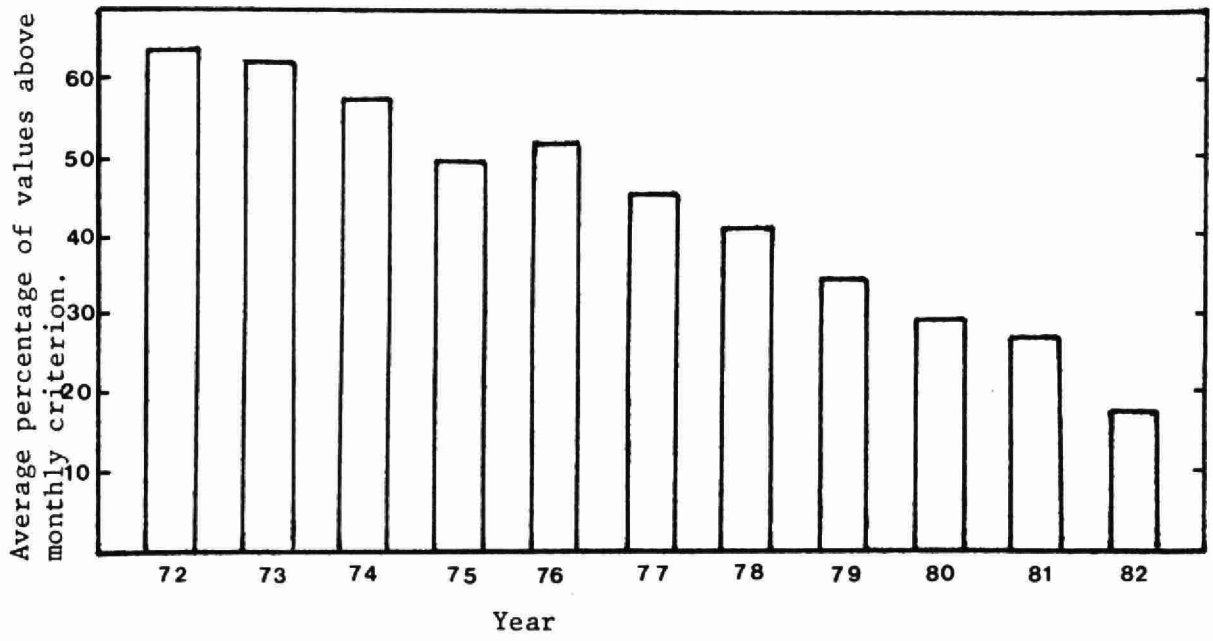
Notwithstanding the downward trend in dustfall levels, during 1982 the annual criterion was exceeded at 10 of the 21 sites where dustfall is measured. The 30-day criterion was exceeded at 13 of the 21 monitoring sites in 1982. As would be expected, dustfall levels are higher in west Windsor, LaSalle and the industrialized area near stations 12013 and 12022. Figure 6 shows the annual averages for dustfall and the frequencies of excursions above the 30-day criterion as determined for the different monitoring stations during 1982. The 1982 dustfall values are listed in Table 2.

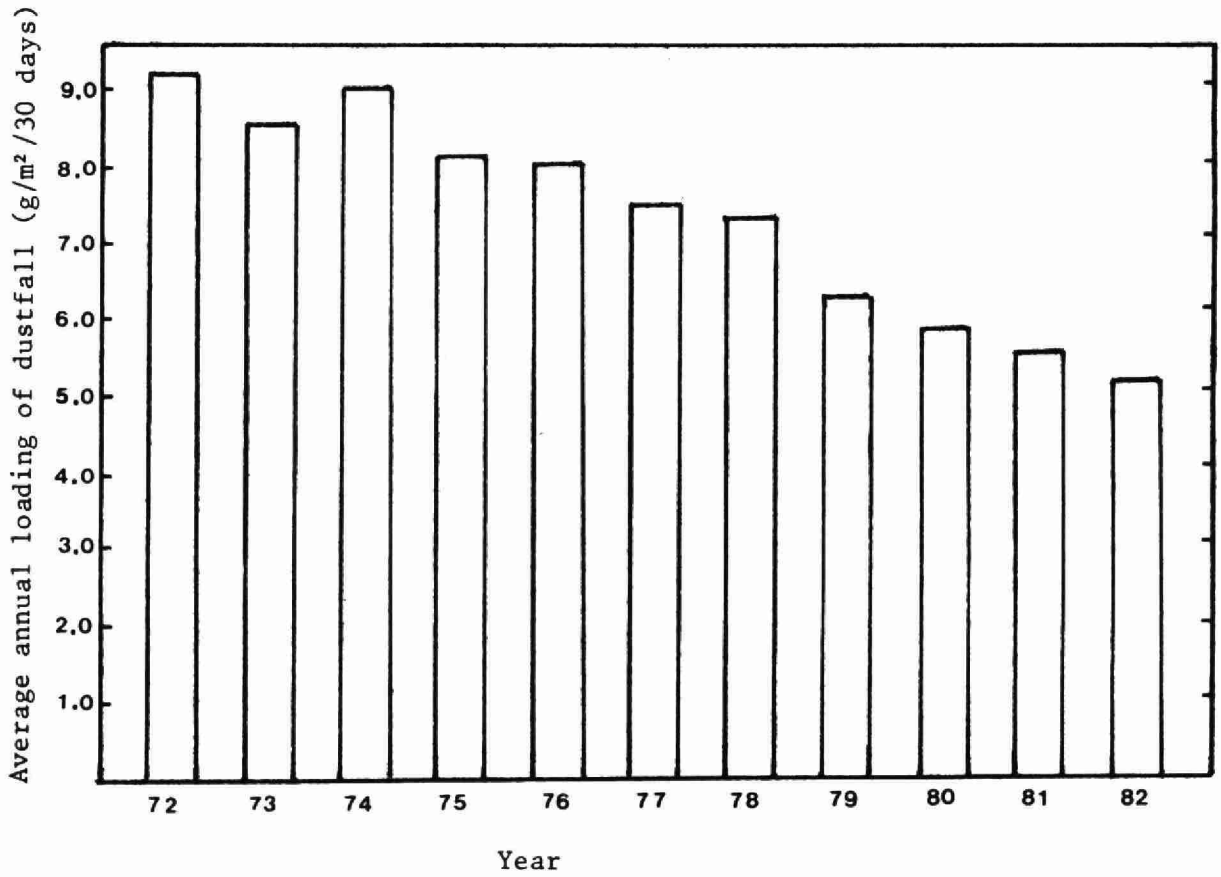
SULPHUR OXIDES

Combustion of sulphur-containing fuels comprises the predominant source of man-made emissions of sulphur oxides. The primary emitters of sulphur oxides are power generating plants and industries utilizing fossil fuels to meet requirements for large amounts of energy.

During 1982 sulphur oxides were measured in Windsor as gaseous sulphur dioxide and as sulphate in

Figure 5. Trend in dustfall levels based on averaged data for fourteen monitoring stations.





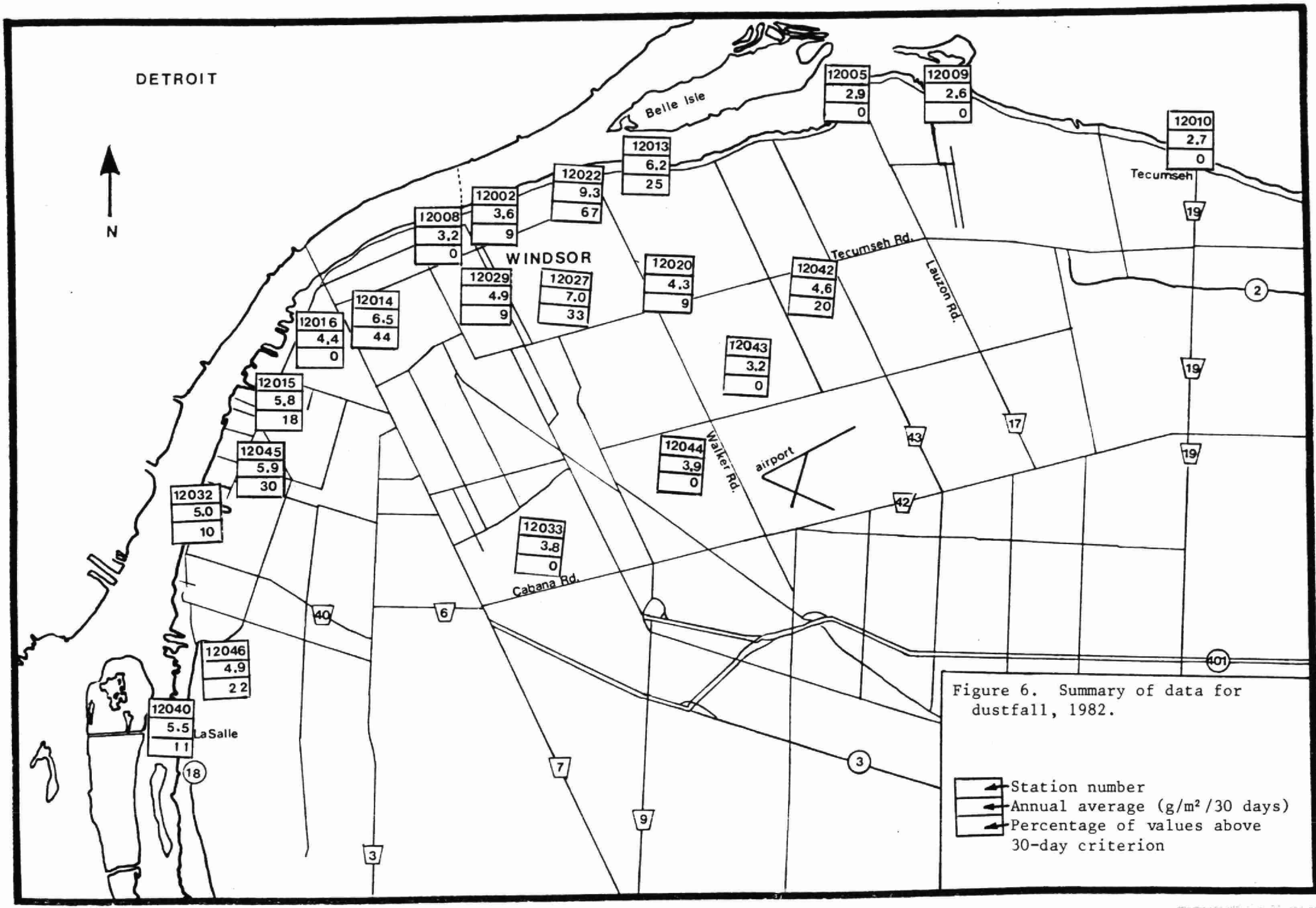


Figure 6. Summary of data for dustfall, 1982.

Table 2. Levels of dustfall during 1982

Station Number	Dustfall loading ($g/m^2/30$ days)												Annual Average	Percentage of values above monthly criterion
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec		
12002	5.4	1.5	7.4	3.1	5.0	3.7	3.6	2.8	3.0	2.4	2.0	--	3.6	9
12005	4.3	1.3	4.4	2.7	5.4	3.0	--	2.9	1.5	3.4	1.6	1.6	2.9	0
12008	2.4	2.6	5.4	3.5	4.4	4.9	3.1	2.3	3.1	2.9	2.0	1.9	3.2	0
12009	5.3	0.5	4.7	2.5	--	2.5	2.4	4.4	2.0	1.4	1.3	1.1	2.6	0
12010	3.8	0.8	--	1.6	--	--	--	--	2.9	4.7	3.8	1.0	2.7	0
12013	14.1	2.9	8.3	6.6	6.2	4.8	7.9	6.8	4.5	6.4	2.8	3.2	6.2	25
12014	7.1	3.7	10.6	7.4	8.2	5.8	4.3	5.5	5.5	--	--	--	6.5	44
12015	7.8	5.6	10.5	6.3	6.7	--	5.7	6.0	3.6	5.2	2.4	4.3	5.8	18
12016	4.9	2.3	6.1	6.3	6.8	5.3	3.4	4.3	4.2	3.2	2.2	3.3	4.4	0
12020	4.9	--	5.3	4.2	5.8	5.0	2.9	3.0	3.5	7.8	2.2	2.5	4.3	9
12022	5.9	3.4	13.8	--	11.7	--	8.8	12.8	11.4	10.8	--	5.2	9.3	67
12027	8.1	6.7	16.7	9.4	9.9	6.8	4.7	5.1	3.2	5.8	3.4	3.6	7.0	33
12029	4.6	3.0	6.7	5.5	6.4	--	5.0	2.9	10.2	4.5	3.3	2.1	4.9	9
12032	6.7	3.1	6.2	6.6	7.4	--	4.7	5.3	--	4.6	3.0	2.8	5.0	10
12033	6.1	2.2	6.3	3.9	6.6	1.8	4.0	--	2.4	5.0	1.6	1.7	3.8	0
12040	7.0	2.8	6.8	4.4	--	9.2	6.0	6.6	3.1	--	3.2	--	5.5	11
12042	--	--	4.3	8.3	8.9	5.1	4.3	3.9	5.6	1.5	2.2	1.6	4.6	20
12043	5.3	1.4	4.0	5.3	5.9	--	3.8	2.8	1.5	2.1	1.6	1.1	3.2	0
12044	2.7	1.5	5.6	3.2	5.0	6.0	3.2	4.0	5.2	--	3.0	3.1	3.9	0
12045	3.6	--	5.0	4.6	--	9.5	8.2	8.0	6.8	3.2	6.6	3.0	5.9	30
12046	4.7	3.2	--	--	8.4	6.1	--	7.7	5.4	2.4	3.2	3.0	4.9	22

suspended particulate matter. Data for sulphate in suspended particulates are presented in Table A4 supporting the section on the Chemical Analysis of Suspended Particulates.

Sulphur Dioxide

The criteria for desirable ambient air quality with respect to sulphur dioxide are 0.25 parts of sulphur dioxide per million parts of air (ppm) averaged for 1 hour, 0.10 ppm averaged for 24 hours (midnight to midnight) and 0.02 ppm as an annual average. The 1-hour and annual criteria were established for the protection of vegetation while the 24-hour criterion serves to protect human health.

During 1982 gaseous sulphur dioxide was measured continuously by the Ministry of the Environment at four fixed locations in Windsor. The monitoring locations are shown on Figure 1 as stations 12008, 12013, 12016 and 12032. The monitors utilized are continuous fluorescence-type instruments. None of the desirable ambient air quality criteria were exceeded at any of the monitoring stations during 1982. A summary of the 1982 data is presented.

Table 3. Summary of 1982 data for sulphur dioxide

Parameter	Station number 12008	12013	12016	12032
Annual average (ppm)	0.01	0.00	0.01	0.01
Percentage of values greater than:				
1-hour criterion	0	0	0	0
24-hour criterion	0	0	0	0
Highest 1-hr value (ppm)	0.15	0.11	0.13	0.13
Highest 24-hr value (ppm)	0.06	0.08	0.04	0.03

Levels of sulphur dioxide have been appreciably lower in recent years compared to levels experienced in the early 1970's. The improvement is illustrated by Figure 7 which shows the frequencies of excursions above the 1-hour and 24-hour criteria for sulphur dioxide as measured at stations 12008 and 12032. The improved air quality is attributable to better control and dispersion of emissions of sulphur dioxide in Wayne County, Michigan and Windsor.

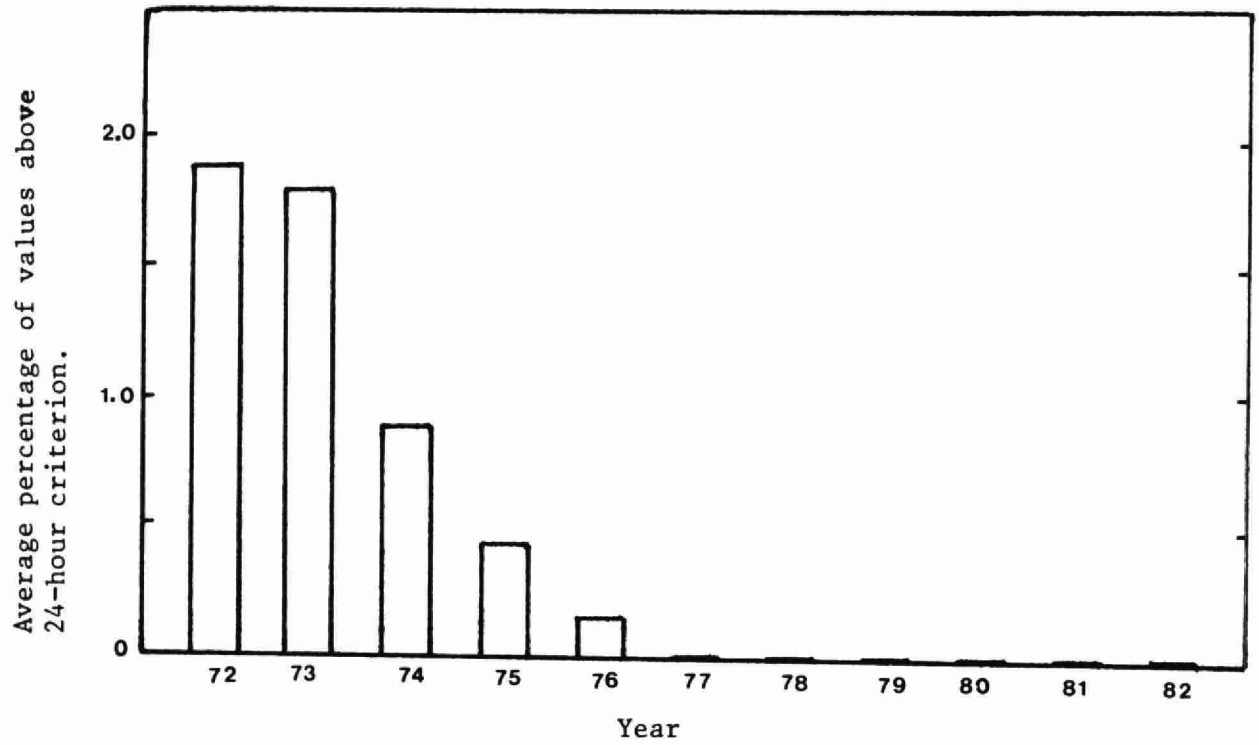
Pollution roses for 1982 levels of sulphur dioxide are presented for each monitoring station in Figure 8. The roses were developed by determining the average concentrations of sulphur dioxide that corresponded to 16 wind directions. Data for wind directions were measured at the 18-metre level of station 12001. The pollution roses indicate an influence from sources of sulphur dioxide in Wayne County, Michigan, but these were not sufficient to cause excursions above the criteria for desirable ambient air quality.

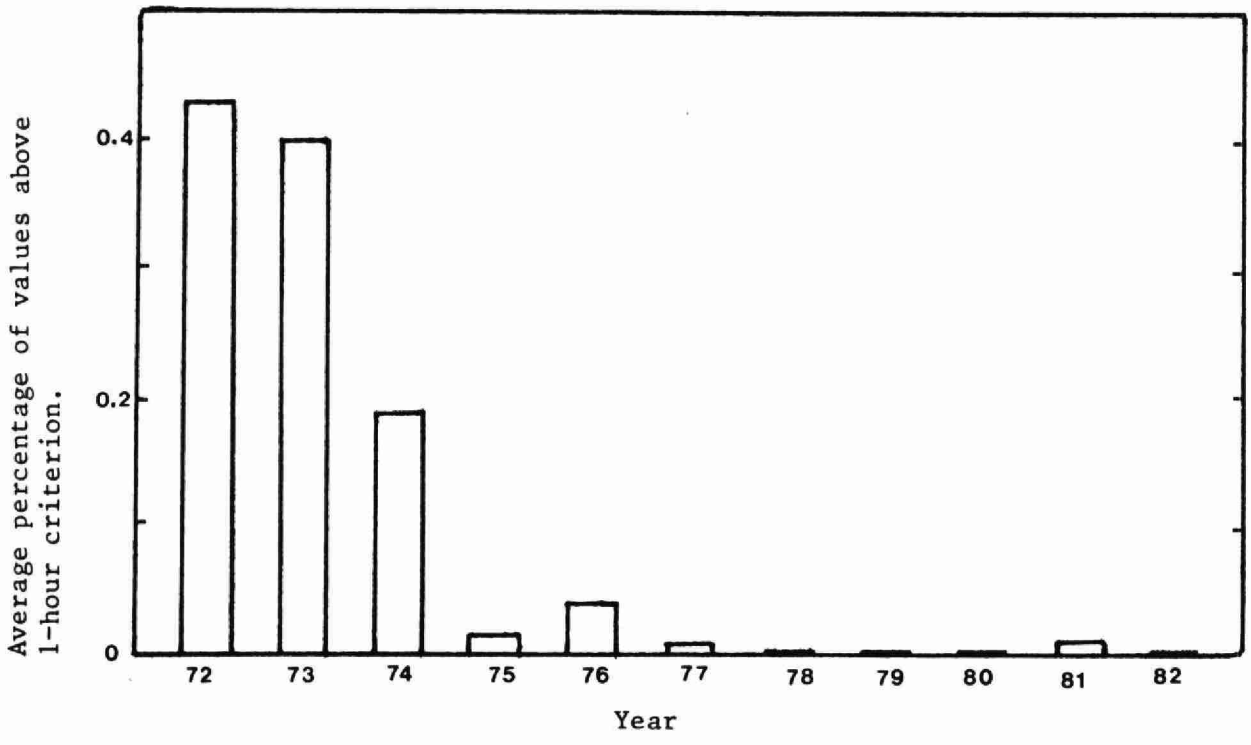
AIR POLLUTION INDEX

The Air Pollution Index (API) is a system designed to control or prevent an air pollution episode. Meteorological forecasting and readings of sulphur dioxide and suspended particulates are utilized to predict the potential for the persistence of deteriorating air quality conditions that are numerically reported as the API.

Data for suspended particulates are provided by the measurement of soiling index and a correlation between concentrations of suspended particulates and soiling index. Hourly values of soiling index and gaseous sulphur dioxide

Figure 7. Trend in frequencies of excursions for sulphur dioxide based on combined data for stations 12008 and 12032.





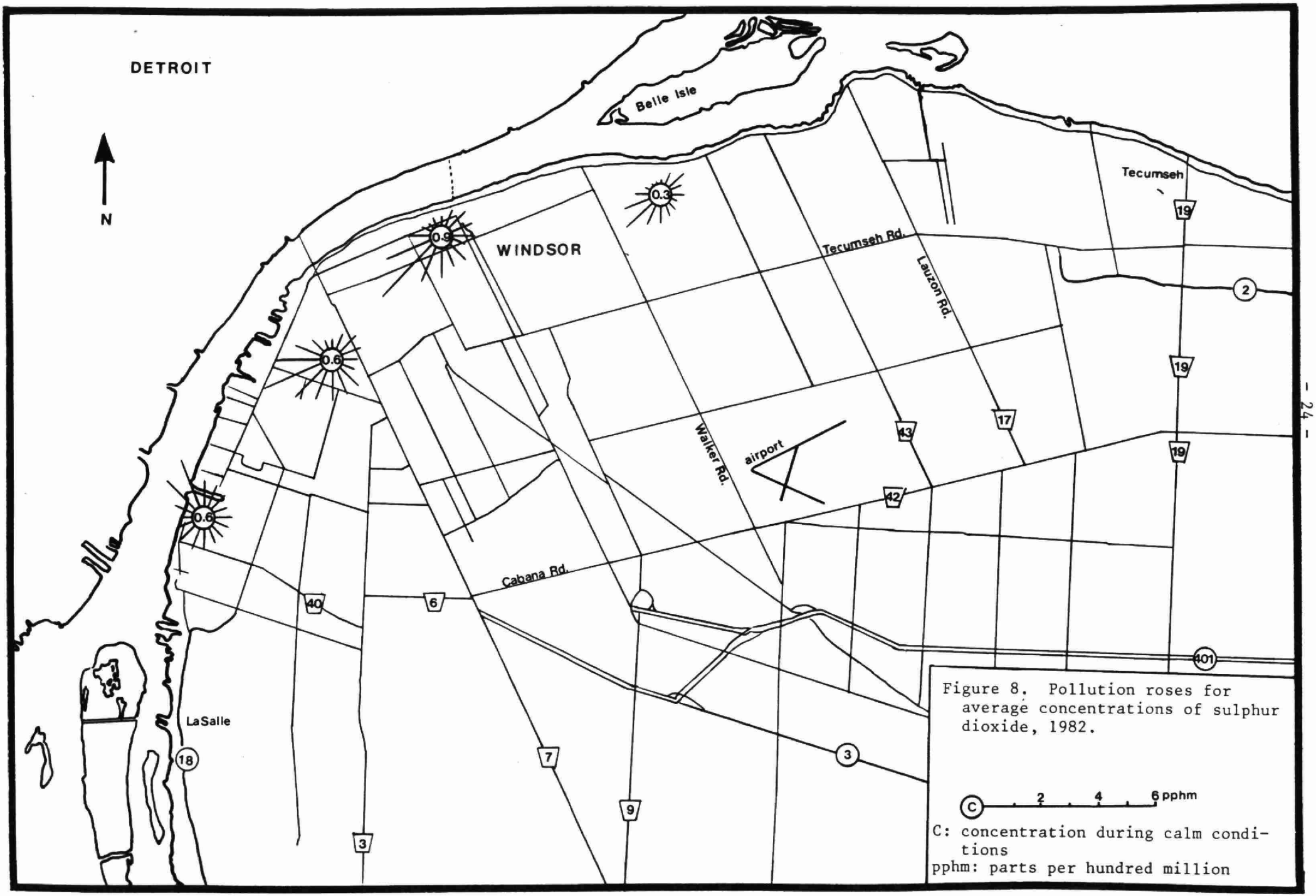


Figure 8. Pollution roses for average concentrations of sulphur dioxide, 1982.

C: concentration during calm conditions
pphm: parts per hundred million

are used to compute 24-hour running averages which are inserted into the following equation:

$$API = 0.78\ (18.26\ COH + 156.7\ SO_2)^{1.06}$$

where: COH is the 24-hour average for soiling index expressed in co-efficient of haze units

SO_2 is the 24-hour average concentration of sulphur dioxide expressed in parts per million.

API values up to 32 are considered acceptable. Values from 32 to 49 are at the Advisory Level and if adverse weather conditions are likely to persist, major emitters are advised to prepare to curtail operations. At an API of 50, major emitters may be ordered to curtail operations. At 75, further cutbacks can be required. If the API reaches 100 all industries and other pollution generating activities not essential to public health and safety can be ordered to cease operation.

Levels of soiling index and sulphur dioxide utilized for the computation of the API are obtained at stations 12008 in downtown Windsor, and at station 12016 in west Windsor. At station 12008 the API did not reach the Advisory Level of 32. On October 27, 1982 the Advisory Level was reached at station 12016 for 12 hours. The maximum API level on this day was 35 and was attributable almost entirely to elevated levels of particulates. Sulphur dioxide levels were normal.

TOTAL REDUCED SULPHUR

Gaseous total reduced sulphur compounds often exhibit malodours at very low concentrations. Hydrogen sulphide is a reduced sulphur compound commonly referred to as rotten egg gas. Mercaptans are also reduced sulphur compounds. There are many sources of reduced sulphur compounds including natural decomposition of organic material. In west Windsor there are occasional malodours which may be caused by reduced sulphur compounds. Probable sources of these odours are the coking operations of the steel industry in Wayne County, Michigan.

Throughout 1982 total reduced sulphur compounds were measured at station 12032, located in west Windsor near Morten Dock. Monitoring began at this station in May, 1981 and therefore there are insufficient data available to determine a significant trend in levels of reduced sulphur compounds. However, 1982 levels were appreciably lower than those of 1981.

The Ministry of the Environment has a desirable ambient air quality criterion for mercaptans of 10 parts per billion (ppb) during a 1-hour period. There is also a criterion for hydrogen sulphide which is 20 ppb during a 1-hour period. These criteria were established on the basis of odour. The instrument used by the Ministry to measure total reduced sulphur compounds does not differentiate between hydrogen sulphide and mercaptans but reports the combined levels of hydrogen sulphide and mercaptans as total reduced sulphur, expressed as hydrogen sulphide. In consideration of the combined levels measured by the instrument the levels are compared with the less restrictive criterion for hydrogen sulphide. Of 8350 concentrations reported for 1982 only one exceeded the 1-hour criterion of 20 ppb. This maximum value was 22 ppb. A summary of the results appears in Appendix 3, Table A5.

The total reduced sulphur compounds were correlated with wind direction data obtained at station 12001 in Windsor to produce a pollution rose. The resulting rose, depicted in Figure 9, indicates that reduced sulphur levels were higher when winds were blowing from the general direction of the coking ovens and other heavy industrial operations in the Zug Island area of Wayne County.

CARBON MONOXIDE

Combustion processes account for man's major emissions of carbon monoxide. Emissions from motor vehicles are especially significant because they occur near ground level and are concentrated in urban areas where the public may be exposed for long periods. Major industries and power generating plants normally provide adequate dispersion for their emissions to prevent unsatisfactory levels of carbon monoxide in ambient air.

The criteria for carbon monoxide are 30 ppm averaged for 1 hour and 13 ppm averaged for any consecutive 8 hours. These criteria were established for the protection of human health and have not been exceeded in the past 7 years, based on monitoring at station 12008. Since this station is located in the downtown area of Windsor where the highest levels of carbon monoxide are anticipated, there is a high probability that levels are acceptable throughout the Windsor area.

A summary of data for carbon monoxide, obtained since 1972, is presented in Appendix 3, Table 5A. Data obtained from 1972 to 1976 are higher than data for the past 6 years. The differences in measured levels are attributed in part to replacement in late 1976 of a less accurate monitoring instrument with a more sophisticated one.

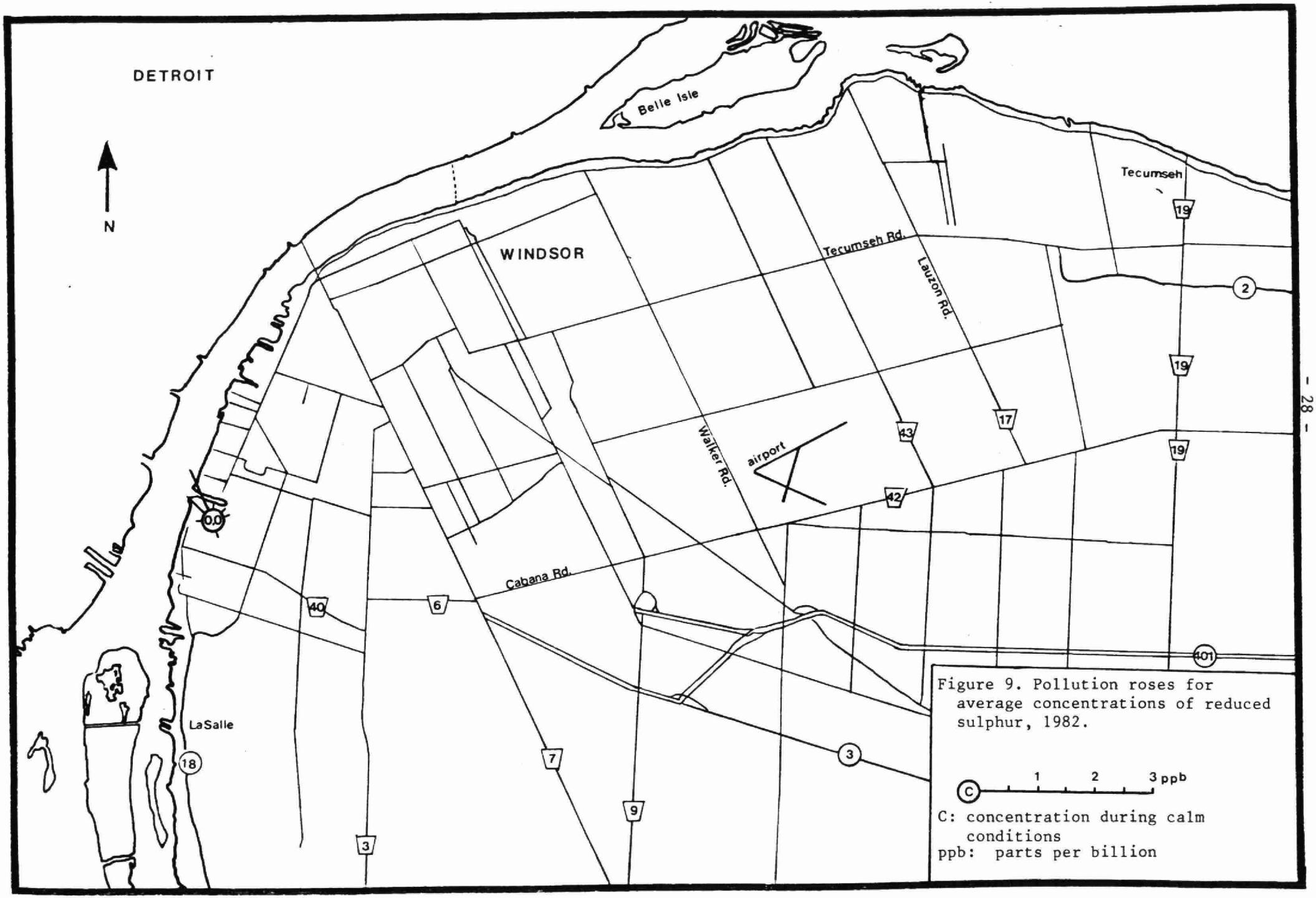


Figure 9. Pollution roses for average concentrations of reduced sulphur, 1982.

C 1 2 3 ppb

C: concentration during calm conditions
ppb: parts per billion

OXIDES OF NITROGEN

Like many other pollutants, oxides of nitrogen are emitted into the atmosphere by man through combustion processes. Nitric oxide and nitrogen dioxide are of primary interest.

Criteria for desirable ambient air quality exist for nitrogen dioxide, but not for nitric oxide or total oxides of nitrogen. The criteria for nitrogen dioxide, which are based on the protection of human health and offensive odours, are 0.20 ppm averaged for 1 hour and 0.10 ppm averaged for 24 hours (midnight to midnight).

During 1982 the criteria were not exceeded and levels of nitrogen dioxide were comparable to previous years. The annual average concentration of nitric oxide was the lowest measured since monitoring started in 1974. The data were determined by a continuous chemiluminescence monitor located at station 12008 in downtown Windsor. Since emissions from motor vehicles are concentrated in the downtown area, levels of oxides of nitrogen would probably be lower in other areas of Windsor. A summary of the data for oxides of nitrogen is presented in Table A5, Appendix 3.

Although levels of nitrogen dioxide have been very favourable when compared to the criteria, there is concern about oxides of nitrogen because of acidic precipitation and their role in the formation of unsatisfactory levels of photochemical oxidants. Consequently, controls for oxides of nitrogen are under consideration.

HYDROCARBONS

The principal man-made source of hydrocarbons is emissions from motor vehicles. Other significant man-made

sources are incomplete combustion of fuels by industries and power generating plants, and evaporation losses during manufacture, use, storage and transportation of materials containing volatile hydrocarbons. In the Windsor area, hydrocarbon emissions from distilleries and distillery warehouses account for a large proportion of the emissions from stationary sources. Natural phenomena produce many hydrocarbons of which methane is the most abundant.

Owing to the wide range of effects associated with different hydrocarbons at various concentrations, no criteria for desirable ambient air quality have been established for total hydrocarbons. Instead, control is achieved by setting criteria for desirable levels of specific hydrocarbons in ambient air and/or establishing standards which control the impact of emissions of specific hydrocarbons.

Although there are no criteria for total hydrocarbons, monitoring for them provides information on trends in levels of hydrocarbons. Increasing levels of hydrocarbons could be significant should they be attributable to detrimental compounds. Furthermore, the non-methane hydrocarbons or "reactive" hydrocarbons may partake in photochemical reactions which produce excessive levels of oxidants.

Total hydrocarbons, methane and non-methane hydrocarbons are monitored continuously at stations in downtown Windsor using flame ionization detection. Levels of total hydrocarbons were similar in 1982 to levels of previous years and no trend of changing levels is apparent. The average concentration of non-methane hydrocarbons was the same in 1982 as in 1981. A summary of annual average concentrations appears in Table A5, Appendix 3.

OXIDANTS

A major portion of the oxidants in ambient air are a result of photochemical reactions and inter-reactions involving oxides of nitrogen and reactive hydrocarbons. The reactions are promoted by certain meteorological conditions such as warm temperatures and intense sunshine. Consequently, higher levels of oxidants are experienced in the spring and summer months.

Ozone normally accounts for 80 to 90 percent of the photochemical oxidants in ambient air and the monitoring technology for ozone is more accurate and efficient than that for total oxidants. For these reasons, most regulatory agencies, including this Ministry, monitor for ozone rather than total oxidants.

Ozone is also present in the stratosphere where it plays the critical role of absorbing ultraviolet radiation that in excessive amounts may be biologically harmful. Occasionally, ozone from the stratosphere may be transported downwards to cause elevated concentrations at the earth's surface. Ozone is naturally produced in minor amounts by lightning.

Long-range transport of ozone and its precursor chemicals (oxides of nitrogen and hydrocarbons) can account for a very significant portion of local levels of ozone. Incidents of long-range transport from distances greater than 200 kilometres have been reported in the literature. Consequently, successful control of oxidants will depend on control strategies implemented in the United States as well as in Ontario.

The Environmental Protection Agency (EPA) in the United States has established a primary standard for ozone

of 0.12 ppm averaged for 1 hour. Individual states are required to bring ozone levels into compliance with the standard by 1987.

The Ontario criterion for desirable ambient air is 0.08 ppm averaged for 1 hour. This criterion was established for the protection of vegetation, property and human health. Some effects detrimental to health that are associated with oxidants are eye irritation and a decrease in performance during physical activities. Oxidant damage to crops in Ontario is estimated at millions of dollars annually. Ontario has established a special section in its Long-Range Transport of Air Pollutants program to study the oxidant situation and to develop a suitable control strategy.

Ozone is monitored by a chemiluminescence-type instrument at station 12008, in downtown Windsor. During 1982 there were 48 hourly values reported in excess of the 1-hour criterion, all of which occurred during the months of May through September. This was the fewest number of excursions recorded above the criterion in any year since monitoring began in 1974. With photochemical formation of ozone being dependent on meteorological conditions, there may be large fluctuations from year to year in the frequencies of excursions above the criterion. A summary of ozone data is presented in Appendix 3, Table A5.

A pollution rose, showing the frequency of ozone values above 0.08 ppm in relation to wind direction, appears in Figure 10. The majority of the excursions above 0.08 ppm are associated with winds from the south-southwest, south and south-southeast. Most of the excursions associated with southerly winds are a result of long-range transport of ozone and its precursors. The abatement strategies being developed in the United States should reduce the number and magnitude of excursions attributable to long-range transport.

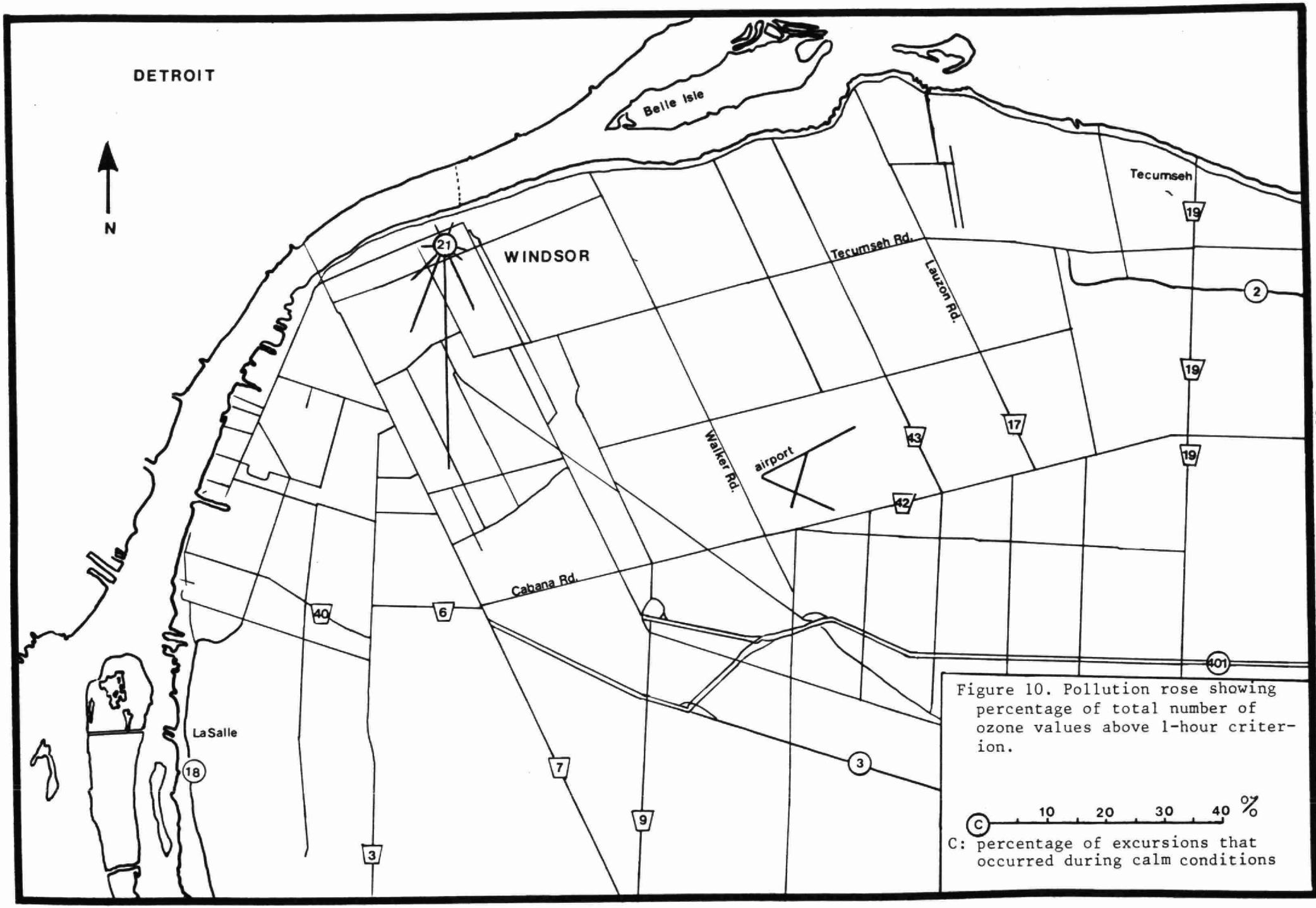


Figure 10. Pollution rose showing percentage of total number of ozone values above 1-hour criterion.

C: percentage of excursions that occurred during calm conditions

FLUORIDES

Sources of fluorides in the Windsor area are the steel industry located in the downriver area of Wayne County, Michigan, power generating plants where coal burned contains trace amounts of fluorides, fluorspar unloading operations at docks in west Windsor and subsequent trucking of fluorspar to a location south of Windsor.

Fluoridation rate is a measurement designed to indicate the relative amounts of gaseous fluoride present over an extended period of time. A lime-impregnated filter is exposed to ambient air for thirty days and then analyzed for fluoride content. This monitoring technique measures primarily gaseous fluoride but some fluoride in particulate form may be collected on the filter.

The criteria for desirable ambient air quality established for fluoridation rate are based on the protection of vegetation. Consequently, a criterion of 40 micrograms of fluoride per 100 square centimetres of filter per 30 days (ug F/100 cm^2/30 days) has been established for the growing season from April 15 to October 15 while a criterion of 80 ug F/100 cm^2/30 days applies to the period of October 16 to April 14. Since the months of April and October are common to both criteria and fluoridation rate is measured on a monthly basis, excursions during these months are determined by comparing the fluoridation rate to the average of the two criteria (60 ug F/100 cm^2/30 days). In recent years, investigations of vegetation have not revealed any appreciable damage to vegetation in Windsor attributable to fluorides.

During 1982 there were eight sites where fluoridation rates were monitored, 5 in west Windsor and 3 in the

downtown area. The growing-season criterion was not exceeded at any station during 1982. The non-growing season criterion was exceeded once at station 12015 in west Windsor and once at station 12022 in the downtown area. Figure 11 shows that in general, higher annual averages for 1982 occurred in west Windsor than in downtown Windsor. The 1982 fluoridation rates appear in Table 4.

Fluoridation rate is not considered a sensitive indicator of temporal trends of fluoride levels. However, based on data from six monitoring sites in operation since 1972, the annual averages for fluoridation rate and the frequencies of excursions above the criteria for desirable ambient air quality have been lower in recent years, with 1982 experiencing the lowest values ever. Figure 12 shows the trend towards lower levels of fluoridation rates.

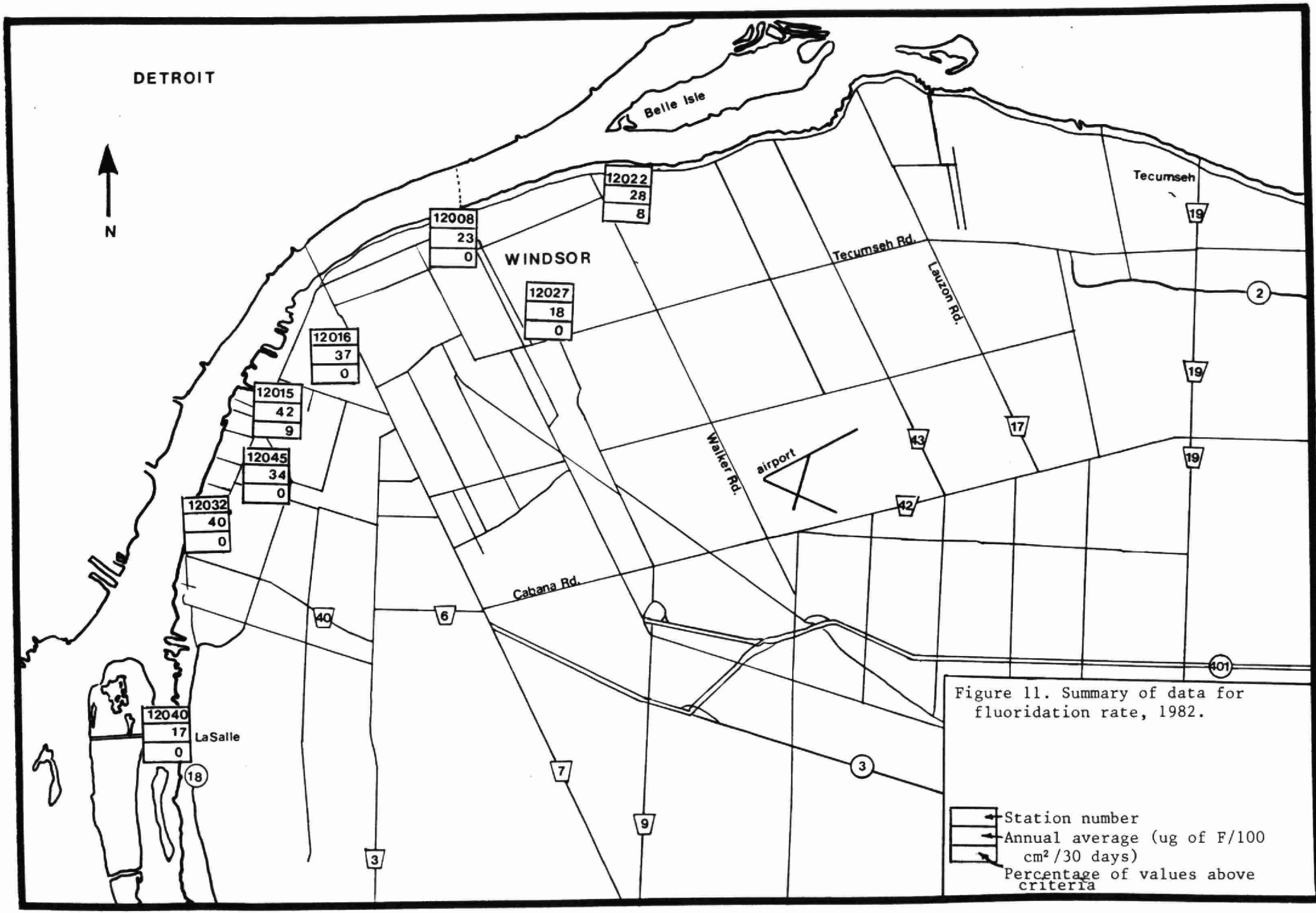
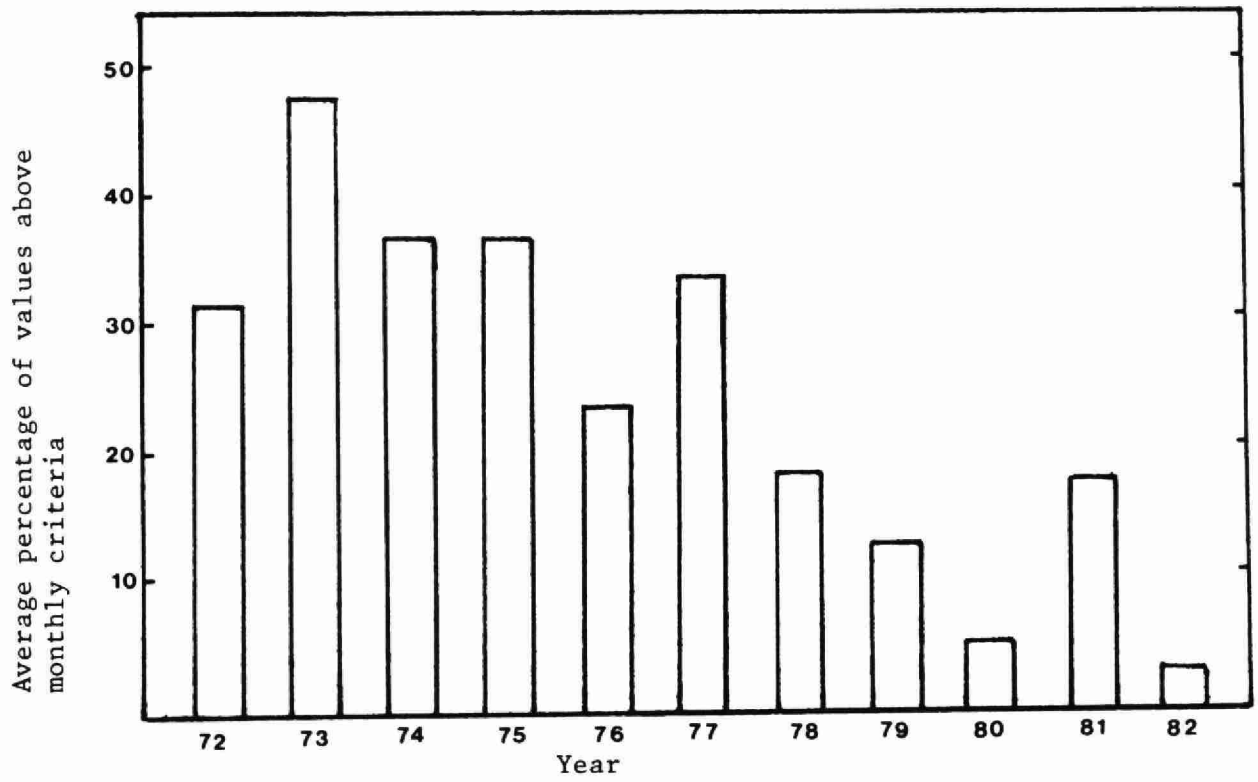

DETROIT
Belle Isle
N
WINDSOR
Tecumseh
Tecumseh Rd.
Lauzon Rd.
Walker Rd.
airport
Cabana Rd.
LaSalle
12008
23
0
12022
28
8
12027
18
0
12016
37
0
12015
42
9
12045
34
0
12032
40
0
12040
17
0
Figure 11. Summary of data for fluoridation rate, 1982.
Station number
Annual average (ug of F/100 cm²/30 days)
Percentage of values above criteria

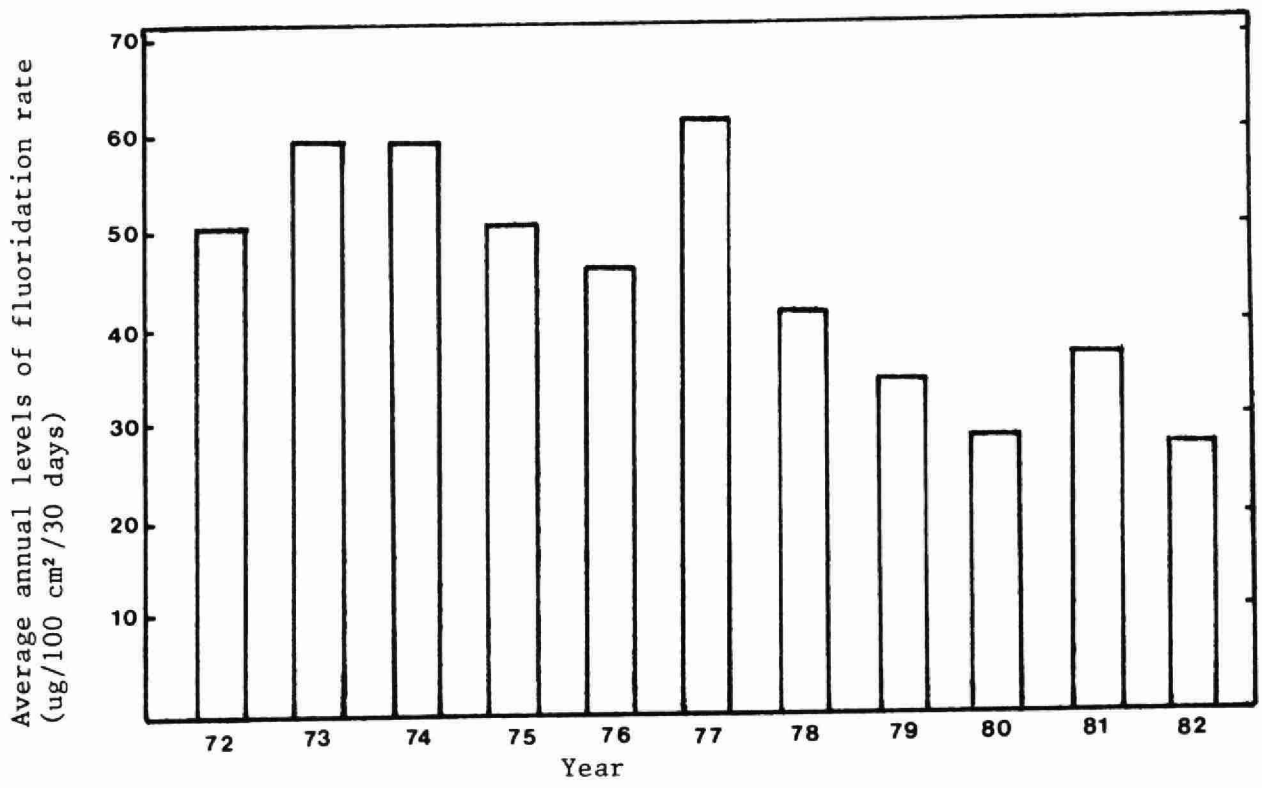
Table 4. Levels of fluoridation rate during 1982

Station Number	Fluoridation rate (ugF/100 cm²/30 days)												Annual Average	Percentage of values above criteria
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec		
12008	34	65	23	23	20	9	6	21	14	17	24	18	23	0
12015	<u>92</u>	71	44	41	28	38	6	--	27	28	42	42	42	9
12016	69	57	54	38	25	10	31	38	20	23	42	32	37	0
12022	45	<u>101</u>	24	22	24	13	15	27	18	20	12	10	28	8
12027	35	31	24	17	19	5	10	19	13	13	14	12	18	0
12032	69	70	42	45	30	34	33	32	--	29	23	29	40	0
12040	40	35	25	17	12	10	9	14	9	9	10	12	17	0
12045	41	78	37	33	26	27	29	32	19	22	--	26	34	0

Note: Underlined values exceed criteria for desirable ambient air quality

Figure 12. Trend in levels of fluoridation rate based on averaged data for six monitoring stations.





APPENDIX 1

DESCRIPTION OF MONITORING NETWORK

Table A1. Locations of air monitoring stations

Station number	Location	Universal transverse mercator projection co-ordinates	Elevation above sea level (metres)	Air intake height (metres)
12001	1.1 km NNE of J. C. Keith Generating Station	03276 - 46839	180	18 & 80
12002	444 Windsor Avenue, City Hall	03323 - 46867	183	17
12005	7730 Riverside Drive East	03395 - 46890	177	10
12008	467 University Avenue	03316 - 46867	183	12
12009	Tecumseh Water Works	03413 - 46888	180	2
12010	Tecumseh Sewage Pumping Station	03460 - 46875	181	1
12013	3665 Wyandotte Street East	03358 - 46874	185	7 & 10
12014	College/California Street	03304 - 46849	185	1
12015	Highway No. 18/Prospect	03283 - 46833	175	6
12016	College/South Street	03290 - 46841	175	4
12020	1869 Albert Street	03363 - 46854	183	5
12022	Hickory/Richmond Street	03352 - 46870	183	5
12027	1526 Parent Street	03340 - 46852	183	5
12029	459 Ellis West	03323 - 46853	185	5
12032	Morton Dock	03271 - 46817	175	4
12033	3501 Longfellow	03335 - 46801	183	5
12036	1794 Westcott Street at Milloy Street	03367 - 46858	186	5
12037	3225 California Street (St. Hubert's School)	03327 - 46816	183	4
12039	Dougall St./E. C. Row W	03337 - 46821	195	5
12040	225 Willow Drive (La Salle)	03261 - 46773	175	5
12042	Princess/Joinville Street	03384 - 46848	185	5
12043	Somme/Chandler	03366 - 46845	183	5
12044	Seymour/Turner	03366 - 46822	183	5
12045	Healy/Sandwich	03276 - 46822	183	5
12046	Adams/Hwy 18	03264 - 46778	175	5

Table A2. Parameters monitored in the ambient air in Windsor during 1981

Station Number	Air Pollution Index	Carbon Monoxide	Dustfall	Fluoridation Rate	Hydrocarbons	Meteorological Data	Nitric Oxide	Nitrogen Dioxide	Nitrogen Oxides	Ozone	Soiling Index (1-hr COH)	Sulphur Dioxide	Suspended Particulates
12001						X							
12002			X										X
12005			X										X
12008	X	X	X	X	X		X	X	X	X	X	X	X
12009			X										X
12010			X										X
12013			X									X	X
12014			X										X
12015			X	X									X
12016	X		X	X							X	X	X
12020			X										
12022			X	X									
12027			X	X									
12029			X										
12032			X	X								X	X
12033			X										
12036													X
12037													X
12039													X
12040			X	X									
12042			X										
12043			X										
12044			X										
12045			X	X									
12046			X										

Table A3. Desirable ambient air quality criteria established by the Ontario Ministry of the Environment

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Carbon monoxide	30 ppm averaged for 1 hour 13 ppm averaged for 8 hours	Protection of human health Protection of human health
Dustfall	7 grams/metre^2 in 30 days 4.6 grams/metre^2 (monthly average in 1 year)	Historial and in keeping with other control agencies
Fluoridation rate	40 ug of fluorides/100 cm^2 of limed filter paper in 30 days during April 15 to October 15	Protection of vegetation
	80 ug of fluorides/100 cm^2 of limed filter paper in 30 days during October 16 to April 14	Protection of vegetation (less restrictive criterion during the non-growing season)
Hydrocarbons (total)	None	Effects of hydrocarbons vary widely depending on their chemical-physical nature
Nitric oxide	None	Reacts with oxygen to produced NO_2
Nitrogen dioxide	0.20 ppm averaged for 1 hour	Protection of human health and protection against odours
	0.10 ppm averaged for 24 hours	Protection of human health and protection against odours
Oxides of nitrogen	None	

Table A3. continued

Parameter	Desirable ambient air quality criteria	Prime reasons for establishing criteria or monitoring parameter
Ozone	0.08 ppm averaged for 1 hour	Protection of vegetation, property and human health
Sulphur dioxide	0.25 ppm averaged for 1 hour	Protection of vegetation
	0.10 ppm averaged 1 day (24 hours)	Protection of human health
	0.02 ppm averaged for 1 year	Protection of vegetation
Suspended particulates	120 ug/m^3 averaged for 24 hours	Based on impairment of visibility and health effects
	60 ug/m^3 (geometric mean) during 1 year	Based on public awareness of visible pollution
Cadmium in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of human health
Lead in suspended particulates	5.0 ug/m^3 averaged for 24 hours	Based on protection of human health
	2.0 ug/m^3 as a geometric mean over a 30 day period	Based on protection of human health
Nickel in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of vegetation
Vanadium in suspended particulates	2.0 ug/m^3 averaged for 24 hours	Based on protection of human health

APPENDIX 2

PARTICULATES

Table A4. Summary of constituents in suspended particulate matter (ug/m³)

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
12002															
1976	12	0.003	0.010	12	0.007	0.022	12	0.11	0.36	12	3.4	8.2	12	0.7	1.1
1977	20	0.006	0.016	20	0.032	0.062	20	0.16	0.52	20	3.1	8.4	20	0.7	1.3
1978	24	0.007	0.035	24	0.018	0.045	24	0.23	0.62	24	3.1	9.9	56	0.7	1.5
1979	28	0.004	0.020	28	0.009	0.026	28	0.08	0.20	27	2.0	5.9	49	0.5	1.0
1980	23	0.002	0.008	23	0.006	0.015	23	0.06	0.16	23	1.5	3.2	51	0.4	2.1
1981	55	0.003	0.024	55	0.006	0.027	55	0.03	0.20	55	1.8	6.9	58	0.3	2.0
1982	51	0.003	0.014	51	0.007	0.090	51	0.05	0.15	49	1.4	4.2	54	0.3	1.0
12005															
1981	59	0.003	0.035	59	0.004	0.030	58	0.05	0.27	59	1.2	13.0	59	0.3	2.6
1982	54	0.005	0.022	53	0.006	0.043	54	0.06	0.67	49	0.7	2.7	54	0.2	1.1
12008															
1976	15	0.001	0.003	15	0.012	0.029	15	0.26	0.45	15	3.3	6.9	15	0.7	1.3
1977	18	0.008	0.025	18	0.018	0.074	18	0.42	1.07	18	4.0	11.1	18	0.8	1.7
1978	23	0.004	0.019	23	0.017	0.045	23	1.13	2.55	23	3.1	9.0	23	0.6	1.8
1979	34	0.004	0.023	34	0.008	0.036	34	0.49	1.62	34	1.9	6.3	34	0.4	1.0
1980	24	0.002	0.008	24	0.004	0.012	24	0.38	1.18	25	1.7	4.1	51	0.4	1.1
1981	307	0.003	0.042	307	0.005	0.043	307	0.15	0.82	307	1.6	7.2	316	0.4	2.0
1982	318	0.003	0.027	317	0.005	0.024	319	0.14	0.68	295	1.2	5.4	313	0.3	1.3
12009															
1978													53	0.4	1.4
1979													47	0.2	0.8
1980													53	0.2	0.7
1981													43	0.1	0.4
1982													53	0.1	1.0

Table A4. Summary of constituents in suspended particulate matter (ug/m³)

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
12010															
1976	12	0.001	0.006	12	0.008	0.026	12	0.12	0.52	12	1.6	5.2	12	0.4	1.0
1977	20	0.002	0.006	20	0.009	0.029	20	0.08	0.24	20	1.2	5.5	20	0.4	0.9
1978	24	0.002	0.007	24	0.007	0.020	24	0.13	0.44	24	1.0	2.5	24	0.3	1.2
1979	32	0.002	0.005	32	0.003	0.015	32	0.19	0.79	32	0.9	2.1	32	0.2	0.6
1980	23	0.002	0.006	23	0.003	0.007	23	0.09	0.21	24	0.5	1.7	23	0.2	0.7
1981	55	0.002	0.012	55	0.004	0.031	55	0.10	0.50	55	0.9	4.4	55	0.2	0.6
1982	57	0.002	0.005	56	0.002	0.009	57	0.14	0.30	52	0.5	1.8	55	0.2	0.8
12013															
1976	17	0.006	0.035	17	0.028	0.113	17	0.15	0.28	22	5.8	21.9	17	0.8	2.0
1977	19	0.007	0.033	19	0.033	0.101	19	0.14	0.35	24	7.2	26.3	19	0.8	1.8
1978	23	0.003	0.012	23	0.032	0.116	23	0.09	0.26	57	6.6	23.1	23	0.5	1.0
1979	22	0.002	0.009	22	0.016	0.055	22	0.13	0.60	56	5.5	29.5	22	0.5	0.9
1980	11	0.001	0.002	11	0.009	0.025	11	0.12	0.37	49	2.6	7.7	11	0.3	0.7
1981	53	0.002	0.011	53	0.008	0.029	53	0.14	0.31	56	1.8	6.4	53	0.3	1.2
1982	56	0.003	0.014	56	0.016	0.089	56	0.24	0.63	53	2.6	8.3	54	0.3	1.3
12014															
1978										54	2.8	8.2			
1979										52	3.0	8.3			
1980										51	2.2	5.4			
1981	49	0.003	0.010	49	0.006	0.026	49	0.15	0.33	54	1.9	6.8	49	0.5	1.7
1982	44	0.004	0.029	44	0.010	0.020	44	0.12	0.28	42	1.6	3.4	42	0.3	1.3
12015															
1978										55	4.0	15.4			
1979										48	3.9	11.3			
1980										52	3.0	8.3			
1981	58	0.004	0.022	57	0.009	0.037	57	0.13	0.29	57	2.5	5.8	57	0.3	1.4
1982	53	0.005	0.074	53	0.008	0.059	53	0.20	3.09	52	2.1	27.1	52	0.2	0.8

Table A4. Summary of constituents in suspended particulate matter (ug/m³)

Station and Year	Cadmium # of samples	Cadmium Avg.	Cadmium Max.	Chromium # of samples	Chromium Avg.	Chromium Max	Copper # of samples	Copper Avg.	Copper Max	Iron # of samples	Iron Avg.	Iron Max	Lead # of samples	Lead Avg.	Lead Max
12016															
1978										56	3.8	12.5			
1979										52	3.1	10.1			
1980										52	2.6	6.2			
1981										10	1.7	3.3			
1982										54	1.5	6.3			
12032															
1976										40	4.1	8.4	15	0.5	1.3
1977										29	3.5	17.9	26	0.5	0.9
1978										49	3.1	9.6	37	0.4	2.1
1979										43	3.6	9.6	58	0.3	1.4
1980										32	2.3	5.8	33	0.3	0.6
1981										56	1.4	8.2	57	0.2	0.4
1982										54	1.4	6.3	55	0.2	0.8
12039															
1978										33	6.3	55.8			
1979										56	3.4	24.6			
1980										54	3.1	37.0			
1981										59	1.8	10.4			
1982										52	1.5	12.4			

Table A4. Summary of constituents in suspended particulate matter (ug/m³)

Station and Year	Manganese # of samples	Manganese Avg.	Manganese Max.	Nickel # of samples	Nickel Avg.	Nickel Max	Nitrate # of samples	Nitrate Avg.	Nitrate Max	Sulphate # of samples	Sulphate Avg.	Sulphate Max	Vanadium # of samples	Vanadium Avg.	Vanadium Max
12002															
1976	12	0.12	0.22	12	0.013	0.027	54	4.9	11.8	54	9.5	35.1	12	0.02	0.03
1977	20	0.11	0.32	20	0.025	0.073	56	4.9	21.6	56	12.5	35.5	20	0.04	0.14
1978	24	0.14	1.10	24	0.016	0.034	52	6.3	20.5	52	14.1	41.1	24	0.00	0.02
1979	28	0.08	0.20	28	0.009	0.015	49	6.8	17.8	49	13.4	28.4	28	0.00	0.03
1980	23	0.05	0.14	23	0.010	0.026	53	6.6	16.9	53	13.8	55.9	23	0.01	0.01
1981	55	0.06	0.20	55	0.011	0.070	58	7.0	19.4	57	13.1	29.7	12	0.01	0.02
1982	51	0.05	0.11	51	0.007	0.027	45	5.4	15.6	51	11.2	37.4	55	0.01	0.02
12005															
1981	50	0.04	0.34	58	0.008	0.085	59	4.9	11.1	58	10.6	28.8	50	0.01	0.03
1982	53	0.03	0.10	54	0.011	0.085	44	4.0	10.1	48	10.5	34.3	54	0.00	0.02
12008															
1976	15	0.11	0.28	15	0.051	0.409	105	4.8	21.6	104	10.7	39.7	15	0.17	1.47
1977	18	0.19	0.48	18	0.026	0.084	48	5.2	23.5	48	13.4	34.2	18	0.03	0.10
1978	23	0.12	0.31	23	0.026	0.059	55	5.3	20.5	55	14.3	57.1	23	0.00	0.03
1979	34	0.07	0.22	34	0.010	0.027	58	6.0	15.7	58	13.7	40.5	34	0.00	0.01
1980	24	0.06	0.15	24	0.014	0.049	52	5.5	16.2	52	11.8	31.0	24	0.01	0.01
1981	307	0.06	0.25	296	0.008	0.041	305	4.9	19.8	297	10.4	44.5	307	0.01	0.03
1982	319	0.04	0.23	318	0.007	0.071	267	4.6	17.3	268	10.4	50.5	319	0.01	0.03
12009															
1979							24	5.2	13.4	24	11.8	25.4			
1980							55	5.3	17.5	55	11.6	24.6			
1981							43	4.5	13.7	41	10.2	26.4			
1982							53	4.1	12.7	53	10.6	32.4			

Table A6. Summary of constituents in suspended particulate matter (ug/m³)

Station and Year	Manganese # of samples	Manganese Avg.	Manganese Max.	Nickel # of samples	Nickel Avg.	Nickel Max	Nitrate # of samples	Nitrate Avg.	Nitrate Max	Sulphate # of samples	Sulphate Avg.	Sulphate Max	Vanadium # of samples	Vanadium Avg.	Vanadium Max
12010															
1976	12	0.06	0.19	12	0.003	0.021	51	3.6	14.2	51	6.9	31.9	12	0.01	0.01
1977	20	0.04	0.20	20	0.019	0.035	52	4.4	24.5	52	10.3	25.4	20	0.01	0.02
1978	24	0.03	0.09	24	0.008	0.019	55	4.5	25.2	55	11.5	44.1	24	0.00	0.00
1979	32	0.03	0.07	32	0.005	0.011	54	5.1	12.6	54	11.5	30.3	32	0.00	0.02
1980	23	0.02	0.05	23	0.004	0.008	53	4.8	10.8	53	10.8	23.5	23	0.00	0.01
1981	55	0.04	0.42	55	0.004	0.018	58	4.5	14.3	58	11.1	36.4	55	0.00	0.02
1982	56	0.02	0.09	57	0.006	0.018	56	3.1	9.7	56	8.8	19.8	57	0.00	0.05
12013															
1976	17	0.38	1.94	17	0.004	0.029	59	4.5	15.0	59	8.3	21.0	17	0.01	0.02
1977	19	0.39	2.02	19	0.031	0.069	54	6.1	32.0	54	13.1	33.6	19	0.02	0.07
1978	23	0.24	0.95	23	0.013	0.058	56	6.6	22.8	56	14.7	48.4	23	0.00	0.03
1979	22	0.15	0.38	22	0.011	0.025	56	7.2	22.9	56	15.0	41.9	22	0.00	0.01
1980	11	0.11	0.47	11	0.007	0.012	54	6.0	19.4	54	13.0	26.9	11	0.01	0.01
1981	53	0.06	0.20	53	0.004	0.017	56	6.3	14.7	56	14.1	33.8	53	0.01	0.02
1982	56	0.15	0.92	56	0.009	0.029	56	4.8	15.4	56	10.9	35.0	56	0.01	0.04
12014															
1981	49	0.07	0.22	49	0.010	0.094	49	5.5	13.6	49	12.6	36.2	49	0.01	0.02
1982	44	0.06	0.21	44	0.012	0.149	44	4.8	16.8	44	13.1	32.2	44	0.01	0.03
12015															
1981	52	0.08	0.22	57	0.008	0.047	55	6.0	17.3	55	14.3	32.3	51	0.01	0.02
1982	52	0.05	0.15	53	0.010	0.102	51	4.6	15.1	51	11.7	28.0	53	0.01	0.13
12032															
1981							57	5.5	18.1	55	13.6	29.3			
1982							55	4.4	14.1	55	11.0	32.2			

APPENDIX 3

TOTAL REDUCED SULPHUR, CARBON MONOXIDE, OXIDES OF NITROGEN, HYDROCARBONS AND OZONE

Table A5. Summary of data for total reduced sulphur, carbon monoxide, oxides of nitrogen, hydrocarbons and ozone.

Parameter	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972
Total reduced sulphur											
Annual average (ppb)	0.1	0.5[a]									
Percentage of values greater than:											
1-hour criterion	0.01	0.006									
Carbon monoxide											
Annual average (ppm)	1	1	2	2	2	2	4	5	5	5	5
Percentage of values greater than:											
1-hour criterion	0	0	0	0	0	0	0	0	0.01	0	0
8-hour criterion	0	0	0	0	0	0	0	0.32	0.30	0.10	0
Nitrogen dioxide											
Annual average (ppm)	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03		
Percentage of values greater than:											
1-hour criterion	0	0	0	0	0.01	0	0	0	0		
24-hour criterion	0	0	0	0	0	0	0	0			
Nitric oxide											
Annual average (ppm)	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.04		
Total oxides of nitrogen											
Annual average (ppm)	0.04	0.05	0.05	0.05	0.07	0.07	0.06	0.06	0.07		
Total hydrocarbons											
Annual average (ppm)	2.1	2.1	2.2	1.9[b]	2.3	2.4	2.6	2.2	1.9	2.1	2.2
Reactive hydrocarbons											
Annual average	0.4	0.4									
Ozone											
Annual average (ppm)	0.018	0.019	0.020	0.016	0.018	0.021	0.021	0.017	0.014		
Percentage of values greater than 1-hour criterion	0.6	1.3	1.8	0.8	2.4	3.1	2.5	2.2	0.8		

(a) 8 months of data
(b) 9 months of data